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CHEMICAL & METALLURGICAL ENGINEERING

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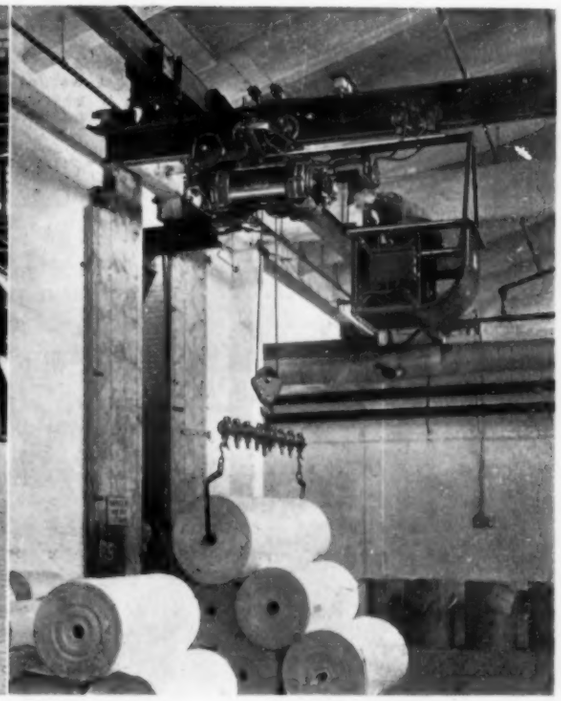

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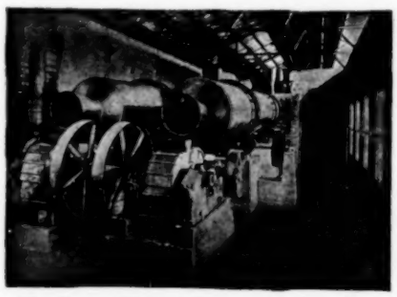

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CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

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A Grand Old Man

THE award of the Perkin Medal to Professor CHARLES F. CHANDLER meets with general approval. There is something about a man hale and wholesome in the ripeness of his years that appeals to the affections of men very much as a beautiful child appeals to women. It was he who put a definite meaning to 66 degree sulphuric acid, and it was he also who fixed standards for the cuts of petroleum sold for lighting and substantially put an end to lamp explosions. He has maintained an open mind and the golden merit of intelligent curiosity all his days. He has walked along the road of a long life with a good word for every neighbor that behaved himself and a cheerful boost for those whose loads were heavy.

He has stood four square and upright for chemistry when the science was in the doldrums of neglectful years, and his many thousands of students rejoice in his friendship and are thankful for his illumination and encouragement.

When he enters a room there is a surge of warmth that makes all hearts beat faster because of the contagious quality of his charity, his enlightenment, and his ever young good fellowship. All honor and praise to him!

Fraudulent Branding Of Imported Articles

OUR attention has been directed to the fact that surgical instruments are being imported into the United States, after which the "country of origin" is polished off or otherwise removed. The substitution of a domestic dealer's name or trade mark then gives the instrument the appearance of domestic manufacture, and the purchaser is consequently defrauded.

The Federal law relating to the removal of the "country of origin" from imported articles, U. S. Tariff Act of 1913, Sec. 4, Par. F, Sub-Sec. 2, reads as follows:

> If any person shall fraudulently violate any of the provisions of this act relating to the marking, stamping, branding, or labeling of any imported articles or packages; or shall fraudulently deface, destroy, remove, alter, or obliterate any such marks, stamps, brands, or labels with intent to conceal the information given by or contained in such marks, stamps, brands, or labels, he shall upon conviction be fined in any sum not exceeding $5,000, or be imprisoned for any time not exceeding one year, or both.

We bring this to the attention of American chemists and metallurgists so that they may be on their guard against similar fraudulent practice in connection with laboratory apparatus or small-scale equipment. No cases of this kind have come to our attention, but the trick may crop out at any time, and we believe a warning is warranted.

Summary Dismissal Of College Professors

THEY have been having another grand row at the University of Saskatchewan and the board of governors has dismissed summarily the heads of four departments, including those of physics and chemistry. There was, it is said, neither a hearing nor a discussion of the subject with the persons involved; they were just fired in the good old way.

We happen to be acquainted with the late head of the department of chemistry, and while we have not heard his story or that of the governors who dismissed him, we are of the opinion that he will not need to look very hard to find employment. But there are far too many of these university rows. The trouble usually has its origin in politics, because a complaisant Governor appoints some old political hacks who are not good for anything else, to serve on the board of overseers. Sometimes the only thing to do is to dismiss certain professors as speedily as possible. Sometimes a public hearing washes so much dirty linen that it is a mistake, a psychological error. Again, it may make a big row out of a little one over a single man in the wrong place. Sometimes a wild man like SCOTT NEARING, late of the University of Pennsylvania, will cause trouble, no matter what happens. But professors are hard to get, and good ones are exceedingly scarce. Teaching is the most subtle of all the arts, and only the gifted ones can really acquire it. The practice involves considerable strain to get the attention of students, and if it is to be kept the student must be made to understand. A professor has to possess, besides scientific knowledge, some of which he has to try to impart to his students, all the wiles of the professional gambler who must arouse the cupidity of his victim, often against his will and better judgment.

The faculty of a university is not a section gang with the trustees acting as joint foremen. They cannot instruct the professors how to teach, for the reason that they don't know how. There is a reasonable dignity of bearing that is and always has been necessary in dealing with those who work with their minds. A gang boss with a lot of laborers under him who cannot be instructed beyond their dead weight may achieve results by yelling and cursing and firing anybody that doesn't push with the rest, but when he advances in rank and becomes head of the corporation he can't talk to his engineers that way.

The fact is, more particularly in regard to state institutions—and this is said with all the reservations and exceptions that the conditions may warrant—we need more culture at the top. Boards of trustees and occasionally a president need the graces of life; for the benefit of all concerned it is desirable that they be gentlemen.

The Railroads And You

A DOZEN years ago "JIM" HILL, whose railroads opened up our great Northwest and who knew railroads, said that the steam lines of this country would require an expenditure of one billion dollars a year to keep them in shape to serve and aid the national growth. They didn't get it; in those days a billion dollars a year was too large to imagine. A part of it was found, but even that part steadily decreased, and during the past three years an unprecedented event occurred in American railroading—the mileage actually decreased. Mileage not only decreased, but equipment did not properly expand, with the result that right now the railroads are working to utmost capacity and there are thousands of tons of freight standing still because there is no equipment with which to move it. Railroads have reached capacity because unified control and its accompanying economies in routing have not been able to increase tonnage perceptibly. That potential freight in huge volume is dormant is evidenced by non-completion of many highway programs due to lack of construction materials, and by statistics showing that during the coal strike the railroads moved nearly twice their usual amount of freight other than coal.

Car shortage, freight and passenger congestion have become endemic, solely by virtue of lack of funds for new construction, until now, as a recent estimate by the well-informed *Railway Age* puts it, six billion dollars and three years time is the minimum by which we can expect relief! How this money and credit is to be provided is a difficult question to answer, and that aspect we do not wish to discuss at this time, but merely aim to draw attention of our readers to undoubted facts with an urgent suggestion that they give their best thought to all available angles of the situation.

The outstanding truth is this: the railroads need, *immediately*, billions of dollars for essential expansion.

But is this an important thing for me? the reader may ask. From the most selfish standpoint one might rejoin, "What engineer is there but will be favorably affected by a construction program involving two billions a year? What person, from capitalist to laborer, but will reap good times from that amount of money put into circulation?" Even the most narrow-minded manufacturer or producer could get behind a program providing new railway facilities, for it would enable him to get his supplies more freely and to ship a larger volume of products with promptitude, an asset difficult to estimate in money value.

A curious thing comes to mind in connection with the poverty of our carriers. They are poor not because there is no money or credit available, for millions are daily going into the flotation of new industrials or the development of older businesses. In order that this investment may earn its expected return, the institutions must be able to do business; but how can they function normally when the railroads could not handle the traffic offered them last year? Without being an alarmist, one could seriously doubt whether we are not at the portal of a financial panic from industrial overexpansion similar to that of the '70s caused by optimistic railroad building. Then, we built railroads into country which had no traffic to carry. Now, we are producing traffic with no railroads to move it.

But finally, each engineer, each American citizen, should consciously work for speedy expansion in sound railway facilities simply because it will redound to the everlasting benefit of the whole people. Unquestionably unrestricted exchange of intelligence and of goods is essential for our national existence. How the thing can be done is a matter where opinions can well differ; the first thing to sink into consciousness as a certainty, however, is that, to avoid national disaster, railroad facilities must keep ahead of the procession.

When we know it must be done, then we know it can be done!

Dewatering Coal in the Byproduct Coke Industry

LONG ago a low-ash coke from a high-ash coal proved to be an easy engineering proposition, for the solution of the problem had been started centuries ago in the hands of the early gold panner and perfected in the modern ore-concentration tables. It was only necessary for the coal concentrator to reverse the usual mineral process by taking his cleaned coal from the tailing discharge of either a Deister or Wilfley concentrator and draw off his mineral-ash impurities at the ore discharge. However, the solution of the ash problem did not remove all the troubles, but only substituted others of only slightly less importance. The washed coal having been in intimate contact with almost thirty times its weight of water comes out from the draining elevators and conveyors with a water content of not less than 16 per cent. Draining for twenty-four hours reduces this to 12 per cent and draining for seventy-two hours reduces it to 10 per cent. Shipment in cars over reasonably long distances often shakes the water content down to 8 per cent. The result is that from 8 to 16 per cent of water is carried into the coke retorts in the various plants throughout the country.

Hot coal possesses an oily water-repellent surface which causes all the free water contained in a coke-oven charge to segregate and flow to the floor of the oven. It is not an uncommon sight to see water flow out at the base of beehive or even byproduct ovens. At any rate, all the water of a coke-oven charge will usually be found in the lower layers which will carry a content as high as 50 per cent of water. The quenching action of this heat conductor swiftly and certainly gnaws its way deep into the refractory silica lining. In one plant the rate of spalling of the brick at the base zone is reported to be an inch and one-half per year. One-fourth this much is said to be exceptionally good practice.

This destructive action of water on the retort walls is an enormous cost, but the simultaneous loss in gas, oil, tar and ammonia is even greater. All the gas must be used in furnishing fuel when coking such wet coal, due to longer coking hours and higher heats being used. One-third of the tar and oil yields is also destroyed where coals containing a high water content are coked, and 25 per cent loss of ammonia helps to swell the losses. It is a safe conclusion that "watered stock" is death to profits in the coke industry as well as elsewhere.

A centrifugal drier capable of handling seventy-five tons per hour with thirty-five horsepower has been put into operation recently, in which well-drained coal direct from the washers has been dewatered to 6 to 8 per cent. Installation of such equipment will be but a slight addition to the average byproduct coke plant. If arrangements could be made to heat the coal, a better separa-

tion would undoubtedly be had in the centrifugal and the water not separated mechanically could be largely volatilized subsequently. What the result of charging dry, warm coal into the coke retorts will lead to is highly problematical, but it will certainly be very profitable. That it will prolong the life of the retorts and give larger yields of byproducts is certain. The big question to be answered is whether it will lead to preheating the coal previous to charging into the coke retorts and make 12-hr. coke possible.

Dr. Percy and the Intellectual Misers

DURING the first half of last century there flourished in England the Grand Old Man of Metallurgy, one of those men before the days of infinite specialization whose erudition embraced not only all branches of his own art, but stretched over philosophy and humanity as well. Fortunately, he had time for the very important task of collating and publishing practically all the available information on metallurgy, a task which he has done so well that research is seldom required to seek out original sources antedating Dr. PERCY'S books. And the fact that he spoke with discrimination may be gathered when it is remarked that, among many other things in non-ferrous metallurgy, he suggested the possibilities of hyposulphite leaching —later utilized in the Patera process for silver extraction—he realized thoroughly the limitations of bag-filtration of fume, and was able to diagnose accurately the effect of oxide in tough pitch copper.

Once, Dr. PERCY, in discussing with Mr. GILCHRIST the causes of some failures in high-sulphur irons, said: "Remember, too, that it is of very little importance to the world who discovers a fact—that is, a truth; but it is of great importance that it should be published as soon as possible, so that the discoverer may repay in some very small measure the almost overwhelming debt that he owes to the labors of others."

His life was a constant exemplification of this thought —in short, Dr. PERCY to his contemporaries and juniors was a teacher and guide whose influence will never vanish. Give us more men like Dr. PERCY and fewer miserly investigators of narrow vision who imagine that because it cost them something to discover a fact they can erect a fence about that atom of Nature with a sign, "No Trespass."

The Steel Needs Of the Railroads

IT IS a common experience of the individual, when considering his own affairs, to find that it is much easier to estimate his requirements, or draw up a schedule of what he wants, than it is to obtain means for meeting the desires. The same conditions as to wants or requirements and ability to meet them obtains also in the case of more public affairs of various descriptions, and then there are controversies. In the case of railroads, for instance, a great many people have been talking about the "needs" of the railroads without giving much thought to the ability of the railroads to pay.

If some of the suggested programs for the railroads were carried out, a very large quantity of steel would be required, and the common viewpoint is that this would mean a great deal for the steel industry. There seems to be little disposition to look at the matter from the other viewpoint—that it would also mean a very great deal of money to the railroads.

One method of approach to this subject of the steel needs of the railroads has been to take the pace at which railroad development proceeded during one period or another in the past, and then compute the amount by which the railroads have fallen short of continuing the expansion, this amount being taken as a deficiency which must be made up.

In arguments of this sort there is very frequently a fallacy, that of not considering the individual activity in question as part of the general industrial activity of the country. Generally speaking, no individual activity can increase indefinitely at a rate out of proportion to the increase in the total activity of the country. This is a perfectly obvious fact, but usually it is noted as to a given activity only when a short-range comparison brings it out. For instance, in the five years, 1895 to 1900, the production of portland cement was multiplied by 8½, while in one year, from 1900 to 1901, the production increased by 50 per cent in addition. Quite obviously that pace of growth could not continue indefinitely, for in a few decades everybody would have to be at work making or consuming cement, and when that point was reached those who were consuming cement would have to begin leaving their jobs to go to work at cement factories in order to maintain the rate of increase in production.

Now in the case of the railroads there are statistics to show that freight movement in ton-miles per inhabitant increased by 50 per cent from 1888 to 1898, ten years, then from the 1898 standard increased 50 per cent in seven years to 1905, and then from the 1905 basis increased 50 per cent to 1916, eleven years. The successive periods in which the freight movement per capita increased by one-half were ten years, seven years and eleven years. Hence, from a narrow viewpoint it might be argued that a corresponding geometric rate of increase should be provided for the future. As a matter of fact, however, these statistics show that there is something wrong. The per capita freight movement was 1,013 ton-miles in the fiscal year 1888 and 3,840 ton-miles in the calendar year 1917. At it dropped to 3,820 ton-miles in 1918, the size of the movement cannot be attributed simply to the war. This proves rather plainly that in future the individual will have to curb his desires for ton-miles. He may get a few more ton-miles each year, but not the same percentage increase year after year. The individual, however, will take care of that. He has other things to do besides consuming ton-miles.

Speaking more generally, we cannot year after year put more and more of our work into one particular activity. When an activity has caught up with the general procession it must simply take its place there. There is one thing we can do, however. Instead of building a lot more freight cars to move nineteen miles a day, we can devise means for making the existing cars carry freight further than nineteen miles a day. We can replace small steam locomotives with large electric locomotives, and instead of double tracking a single track road we can signal the single track and make it yield more service.

All this will require careful planning, and it is along such lines quite largely that the railroads are going to develop, not along the line of rushing to buy indiscriminately rails, cars, locomotives and bridges just like those that have been bought in the past.

Readers' Views and Comments

Melting Non-Ferrous Metals and Their Alloys in the Electric Furnace

To the Editor of Chemical & Metallurgical Engineering

SIR—The article entitled "Melting of Some Non-Ferrous Metals and Their Alloys in Electric Furnace," which appeared on page 673 of your Nov. 26-Dec. 3 issue, is one of great interest to the brass industry in general, and particularly to those firms and individuals that are making an intensive study of the economics involved in electric brass-melting. It would be well if every technical or semi-technical writer who discusses this subject would employ the same comprehensive and meticulous attention to detail which characterizes Mr. Collins' article.

Nor should the author be expected to give equal space and attention to each of the several electric furnace types now in commercial use for the melting of brass. He is describing a comparatively new type of furnace, hardly out of the experimental stage as yet, and, in a commercial sense, almost unknown to the brass-melting industry. Naturally he describes in considerable detail the design and performance of the furnace in which he is particularly interested, and discusses others only in a comparative way, particularly with reference to those points in which he considers his own design to be superior. Under these circumstances, it should merely be required that the author confine himself to the facts, and be reasonably fair, as well as accurate, in his comparisons. An inference which leads to an inaccurate conclusion in the mind of the reader is as misleading and as dangerous as a deliberate misstatement of fact.

In the article in question one such inference has certainly been made, possibly through ignorance of the real facts. Perhaps it should not be expected that one who has concentrated intensely upon the development of a single furnace design should, at the same time, have a broad, general knowledge of the field and of the equipment which is already in commercial use for the purposes he has in mind. On page 674, after classifying electric furnaces as, (I) solid resistance type, (II) liquid resistance type, and (III) arc type, the author discusses the application of these three types to the melting of non-ferrous metals as follows:

> In the making of brass, furnaces lying in each of the three classes have been tried out. Furnaces lying in Classes I and II lend themselves readily to the generation and control of a mild, "soaking" heat such as is required for melting volatile alloys. As illustration, the common resistance furnace lies in Class I, and the induction furnace in Class II. Furnaces in Class III generate a too intense and burning heat to be used with even questionable success in melting volatile alloys without the use of much unnecessary manipulation and watchfulness requiring much skill. Control of the electric arcs in atmospheres high or low in volatile gases, freedom from surging, low power factor and high metal loss are some of the serious problems confronting the man who would melt volatile alloys in the Class III arc furnace. Their employment had best be left for steel.

Is it not reasonable to suppose from the substance of the above paragraph that the arc type of furnace has been thoroughly tried out for melting brass and has proved a failure; that it is not and cannot be used for the purpose mentioned? That would appear to be the unmistakable inference. What are the facts? There are at present in commercial use for melting brass in the United States four distinct types of electric furnace, counting the one described by Mr. Collins. Three other types, limited in their use to a single installation in each case, may be neglected. In all there are about 200 of these furnaces, with a melting capacity in the neighborhood of 400,000 tons of brass and other non-ferrous alloys per year. Fifty of these furnaces, or 25 per cent of the total, are of the arc type. The induction furnaces in use are all of small size, while the resistance furnaces, with their "mild, soaking heat," melt metal very slowly and have a correspondingly small annual production. As a consequence, out of 400,000 tons total annual capacity, approximately 250,000 tons must be credited to a single type of arc furnace, familiarly known as the "rocking electric furnace." In other words, more than 60 per cent of the annual production of electrically melted brass is from the arc-type of furnace.

Is it going too far to say that the inference of the quoted paragraph is misleading and therefore dangerous?

The specific objections to the arc-type of furnace, listed by Mr. Collins, are: Difficulty of control, power surges, low power-factor, and high metal loss. These objections are based on theory, definitely disproved by experience. So far from requiring exceptional skill, most "rocking" furnaces are operated by men of quite ordinary intelligence who have received perhaps a week's training before taking complete charge of the furnace. Power input to the furnace is very steady and there are no surges objectionable to the power supply company, which, after all, is the party most interested in this phase of furnace operation. These furnaces consistently operate at a power factor from 85 to 95 per cent, which is entirely satisfactory to the most exacting power company. As for metal loss, the values shown in the table herewith, taken from the everyday experience of five representative plants with rocking arc furnaces, are better than those claimed by Mr. Collins for his furnace and, on the whole, rather better than the best figures so far reported for any other type of electric furnace.

OPERATING PERFORMANCE DETROIT ROCKING ELECTRIC FURNACE

Plant	Metal	Melting Time	Daily Production Tons in 9 Hr.	Kw.-Hr. per Ton	Gross Metal Loss, per Cent	Net Metal Loss, per Cent
Foundry	Yellow brass	1 hr., 13 min.	5	299	....	0.9
Foundry	Red brass	1 hr., 1 min.	6	280	0.44	....
Rolling mill	Yellow brass	57 min.	6	262	....	0.9
Rolling mill	Yellow brass	51 min.	6	224	....	1.02
Rolling mill	Yellow brass	43 min.	6	206	1.0	....

It should be noted that in four cases out of five these metal loss figures are for yellow brass—containing, in the case of the three rolling mills, from 37½ to 40 per cent zinc—and that the losses actually experienced are approximately one-third lower than those claimed by Mr. Collins for his furnace. In the case of the foundry melting red brass, the *gross* loss is less than one-half of 1 per cent, more than one-third lower than the value claimed by Mr. Collins for similar alloys.

The author of the paper has accurately listed and summarized the general advantages of electric melting.

but in stating the elements of design which must be incorporated in the electric furnace in order to realize these advantages, he has apparently been influenced almost entirely by his own experience with the resistance-type of furnace. The writer of this letter wishes to take the following exceptions to the statements made.

1. While, in order to avoid excessive maintenance costs, it is necessary to employ a "mild, soaking heat" in all furnaces which heat their refractory linings and roof to a temperature considerably above the pouring temperature of the alloy, this gentle and inefficient method of heating is entirely unnecessary in the arc furnace, where the source of heat is much nearer to the metal than to the refractories.

2. Similarly, volatile alloys do require gentle heating if they are melted in a quiescent bath, no matter how shallow, but may safely be heated much more rapidly and efficiently if the metal is stirred vigorously by the rocking motion of the furnace, and lack of uniformity in heating thus eliminated.

3. Properly speaking, a resistance furnace cannot be forced, nor a high rate of melting attained while melting brass, without seriously shortening the life of the refractories and increasing the metal loss.

4. The author states: "If the source of heat is such that its temperature lies in the temperature zone safely below the destructive distillation point of the metal, then the bath can in no manner exceed it." True enough, but in melting yellow brass (65 per cent copper, 35 per cent zinc) which requires to be poured at 1075 deg. C. and boils at 1115 deg. C., a heat source which did not greatly exceed the latter figure would never succeed in bringing the metal up to the specified pouring temperature. Even with red brass, where the range between pouring temperature and boiling point is much greater, the same thing is practically true.

It has long been admitted that the electric-arc furnace inherently possesses qualities of simplicity, reliability, efficiency and melting speed which cannot possibly be equalled by the resistance furnace. For this reason, the arc furnace is used almost exclusively in melting steel. In the case of brass, the only valid objection to the arc furnace has been that rapid heating of a volatile alloy, coupled with lack of uniformity in the application of heat—a characteristic of all stationary furnaces, whether arc or resistance—resulted in an excessive metal loss. That this difficulty has been completely overcome by rocking the furnace during melting, and so stirring the metal as to keep it thoroughly mixed, can be testified to by every user of this type of furnace, as exemplified in the instances given in the table.

In the interests of perfect fairness, it should be added that Mr. Collins has not been entirely just to the fuel-fired crucible furnace. It must be admitted by every proponent of electric melting that the electric furnace is far more costly in its initial installation than an equivalent installation of combustion furnaces. This initial handicap is, of course, readily overcome by the far greater operating economy of the electric furnace, but any fair comparison between the two should include, as an operating charge, a reasonable sum for interest and depreciation on the investment. This often means an item of a dollar or more per ton of metal melted, in favor of the combustion furnace. To ignore this item, and at the same time include a charge of 10c. per ton against the crucible furnace as interest on the cost of crucibles held in stock, which the author has done in Table I, page 677, is an absurdity.

There are other points in the article, both technical and economic, to which exception might reasonably be taken, but the above discussion covers the more important ones. The principal point for emphasis is that the article states, by implication at least, that the arc furnace is entirely unsuited for melting brass and cannot properly be used for that purpose. The fact that considerably more than half of the electrically-melted brass in the United States, including both red and yellow alloys, is melted in the rocking arc furnace is perhaps a sufficient answer to the statement. It might be added, however, that no arc furnace of this type has ever been rejected by the user as unsatisfactory in its performance, which is more than can be said of any other type of electric brass furnace, with the probable exception of the induction furnace.

H. M. St. John.
Detroit Electric Furnace Co.,
Detroit, Mich.

Dangers of Denatured Alcohol

To the Editor of Chemical & Metallurgical Engineering

Sir—Many of the daily newspapers and other publications have been filled recently with scare heads in which "wood alcohol" has been prominently featured as responsible for many deaths which have taken place among the more ignorant and debased (or at least thirsty) of our population at widely different locations.

Wood alcohol is now sold at about three times the cost of fully denatured alcohol and is not available in large quantities at drug stores, and its sale is not pushed.

On the other hand, denatured alcohol must contain by law 10 per cent of an especially poisonous wood alcohol containing, according to regulations, 10 per cent of acetone and other ketones and aldehydes which are much more poisonous than methyl alcohol. This denatured alcohol is for sale at all drug stores in convenient packages and is advertised at garages for use as an antifreezing remedy.

Prof. Baskerville (Chem. & Met. Eng., Dec. 10-17, 1919, and elsewhere) has warned against wood alcohol and quoted the internal revenue regulations which emphasize the poisonous properties of fully denatured alcohol.

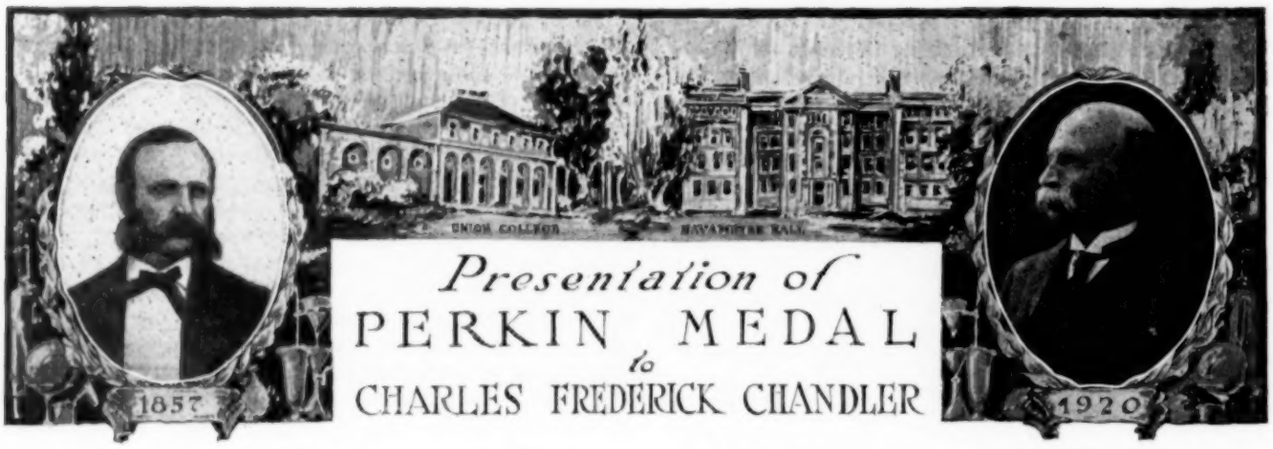
It is our professional duty to warn the public that drinks composed of *denatured alcohol* crudely doctored up will be the most likely poisonous drink to be offered surreptitiously and to caution against this danger.

H. O. Chute.
New York, N. Y.

Electrochemists Discuss Cyanide

The New York Section of the American Electrochemical Society devoted its meeting on Jan. 23 to a discussion of cheap processes for the production of cyanide. Herbert Philipp reviewed past and present methods of manufacture, pointing out the advantages and disadvantages, and also reviewed the uses of cyanide, which are mainly in the metallurgical industry for the treatment of gold and silver ores; for the fumigation of buildings, vessels, trees and food products; electroplating and case-hardening. There is apparently a market in the United States for 25,000,000 lb. per year.

W. S. Landis described a new cyanide product which has found extended use in the metallurgical industry for the treatment of gold and silver ores. Both papers will be published in full in early issues of this magazine.



Presentation of PERKIN MEDAL *to* CHARLES FREDERICK CHANDLER

AFTER introductory remarks by Charles E. Sholes, chairman of the New York section, at the fourteenth annual Perkin medal presentation meeting of the Society of Chemical Industry, Friday night, Jan. 16, and some humorous reminiscences by Dr. M. C. Whitaker, who has been intimately associated with Prof. Chandler for the past twenty years, the Perkin medal was graciously presented to Dr. Chandler by Prof. Marston T. Bogert of Columbia University. Abstracts of the addresses follow:

Personalities

BY M. C. WHITAKER

To attempt to tell you something new about the personal side of Dr. Chandler's career is a difficult undertaking, when speaking to people who have been his friends and associates for years. It seems on second thought, however, in view of my twenty-one years of intimate acquaintance with him, that I might be able to recall a few instances to illustrate prominent characteristics and record the impressions which these observations have left upon my mind.

Tact is one of Chandler's great achievements.

It used to be, and probably still is, a source of great amusement to the students in the upper laboratories of Columbia to drop paper bags filled with water on the heads of pedestrians. Now and then, when marksmanship is good, they hit a Fifth ave. bus.

On one occasion, the victims were two handsomely gowned, unusually dignified, middle-aged ladies of evident social position. They swung into the Havemeyer Building, almost immediately after the accident, fairly sputtering with indignation and rage, and were met at the door by the ever-ready Chandler. They were somewhat disarmed by his genial smile, glistening eye and ready wit, and accepted his invitation to his office to discuss ways and means of properly punishing wayward students. Tea was served with liberal proportions of a flavoring extract made in New England, but named after what is destined to be a famous West Indian island. Negotiations leading to the punishment of the students soon began to take a more hopeful trend, and in the course of half an hour the two ladies left the building, much improved in spirits, with their anger and rage replaced by smiling countenances and very audible laughter.

CHANDLER'S GENEROSITY

Chandler's earnings from his profession probably far exceed those of any other chemist in America. His generosity to others, however, keeps pace with his earnings. No one knows, not even Chandler himself, of the great financial assistance which he has given to many students. A few years ago an old Columbia graduate, unknown to most of us, died in the far West, and provided in his will that the money loaned him by Chandler from time to time should constitute the first claim upon his estate. It was with a great deal of difficulty, and without much assistance from Chandler, that we were able to determine how much money was involved. It turned out to be several thousand dollars, in loans scattered over many years.

There are doubtless many cases of this kind, because during the forty-six years that Chandler was dean of the School of Mines, he was the friend, confidant and father confessor of every one of that great army of students whose troubles are innumerable. It is out of the question for a man of Chandler's tender heart to refuse needed aid to a student. In proportion to his wealth, he gives away more than any American millionaire.

His money is not spent on automobiles, yachts, fine wines or lobster palaces, but is spent on others.

CHANDLER'S COLLECTION

A few months ago I was invited to attend the private exhibition of the household effects of a late citizen of New York, chiefly known for his diamonds. As I stood in the center of a special room, gazing at the wonderful collection of necklaces, bracelets, handbags, slippers, garters and stockings, I was suddenly struck with an idea. I thought of the Chandler Museum at Columbia, and recalled the innumerable times when Chandler would rush up to the University and disgorge from his pockets the most mysterious collection of teacups to illustrate some particular kind of porcelain, saucers typifying a style of decoration, vases of wedgwood, decanters showing particular design of cutting or etching, wine glasses with special features, napkin rings and even spoons. I wondered if there was anything in common between Chandler and "Diamond Jim," and then my thoughts turned to what a place must have looked like after a *joint raid* by these two collectors.

I have touched briefly upon Chandler's intuition, his ability to inspire others, his good fellowship, his tact, his good will toward others, and his hobbies. It seems to me that all of these qualities go to make up a great case for the human side of Chandler's character. I believe that we should write in large letters, and place high in the list of his distinguished achievements, and in words which I must leave to others to coin, something to express the human side of Chandler.

Presentation Address

BY MARSTON TAYLOR BOGERT

Dr. Chandler, Ladies and Gentlemen: The accomplishments of sixty years of tireless, skillfully-directed activity cannot be reviewed in the brief time at my disposal this evening in more than a hasty, imperfect and superficial way, and I know that my colleagues fully appreciate the magnitude of the task assigned me and the impossibility of telling Dr. Chandler in any one evening all that we would like to say in eulogy of his many notable contributions to civilization and in expression of our affection for him personally.

A day for toil,
An hour for sport,
But for a friend,
Life's all too short.

[After reviewing the ancestry, boyhood and educational training at Harvard, Göttingen and Berlin, where Dr. Chandler received the degrees of A.M. and Ph.D. in 1856 when but twenty years of age, Dr. Bogert gave an account of his teaching at Union and Columbia.]

AS EDUCATOR

In January, 1857, Dr. Chandler was appointed assistant to Prof. Joy at Union College, Schenectady, N. Y., and in the spring of that year they opened the chemical laboratory there, enrolling six students in the first class. In those days, Union was one of the largest colleges in the United States, ranking even Harvard. The place was designated as an assistantship, but the budget item provided, namely, $400, was for a janitor, and, as a matter of fact, the new incumbent actually did janitorial service as well as teaching, making the fires, carrying the coal and ashes, and doing other tasks of like character. In April of the same year, Prof. Joy was called to Columbia College, and Dr. Chandler succeeded him at Union, lecturing to 150 seniors, most of them older than their teacher. The late United States Senator Warner Miller was a later pupil.

Little attention had been paid at Union to instruction in the sciences, so that permission was obtained without difficulty to introduce new courses from time to time, with the result that he was soon giving lectures in general, inorganic, organic, analytical, and agricultural chemistry, blowpipe analysis, mineralogy, and geology.

For more than seven years he remained at Union in charge of the laboratory and lecture work in chemistry and other subjects, rapidly building up a strong and influential branch of the college's work.

COLUMBIA SCHOOL OF MINES

Union College possessed a wonderful collection of minerals which had been gathered together by Charles M. Wheatley of the Wheatley and Perkiomen mines of Pennsylvania, and had been purchased for the College by Mr. Delavan, owner of the Delavan House at Albany, N. Y., for $10,000.

It was the existence of this splendid collection of minerals that brought Dr. Egleston to Schenectady in 1864, and made him acquainted with Prof. Chandler. He was somewhat startled to see the latter conducting commercial assays of ores for gold and silver, and to learn that he gave lectures on the subject also, as he had been under the impression that only the graduates of foreign schools of mines were equipped to do work of that nature. This was one of the things that led Dr. Egleston to the conclusion that Chandler was the man needed to join General Vinton and himself in the project of establishing a school of mines in New York City as part of Columbia College. A formal invitation arrived not long afterward, and Dr. Chandler signified his acceptance. To the credit of his deep sense of patriotic duty be it recorded that he delayed his departure from Schenectady until after election day, 1864, in order that he might not lose his vote for Abraham Lincoln.

FEW TECHNICAL SCHOOLS AT THAT TIME

There were at that time but few technical schools in the country, and no school of mines, and many people regarded this project of founding a school of mines in New York City as decidedly visionary and unpromising. Nevertheless, the three professors concerned were so enthusiastic on the subject and had such faith in its ultimate success that they agreed to undertake the work without any guaranteed salary whatever, other than the fees from such students as might register for the course.

George T. Strong, William E. Dodge, Jr., and several other good friends provided a total of about $5,000 to equip the laboratories. A fine cabinet of minerals was donated by Gouverneur Kemble, and President Barnard, Dr. Torrey and other Columbia trustees encouraged the enterprise in every way possible.

Some vacant rooms in the basement of the old college building on Madison Ave. and 49th St. were fitted up for the laboratories and accommodation there provided for twelve students. The new school opened its doors Nov. 15, 1864, and twenty-four students presented themselves for admission on that date. Chandler has often told, in his own inimitable way, how he used to open the laboratory at 7 a.m., start the fire to warm it up, sweep and clean the room, and do all in his power to make the place as attractive as possible and the lot of the students a pleasant one. It was inevitable that there was passed on to these students at the same time some of his own overflowing energy and enthusiasm.

GROWTH OF THE SCHOOL

The school was a phenomenal success practically from the beginning. During the entire winter, carpenters and plumbers were kept busy installing new desks for new students, and the number of students for the first year finally rose to forty-seven. During the following vacation a large four-story factory building on the campus was placed at the disposal of the school, and sufficient funds were provided to equip it with suitable laboratories, lecture rooms, etc. Accommodations were arranged for seventy-two students. Eighty-nine registered for the second year and the school was thronged. The success of the venture being so great and so obvious, the trustees finally arranged to place it on a substantial basis as an integral part of the college work. Prof. J. S. Newberry was called to the chair of geology, relieving Chandler of this subject, and a complete faculty of professors and junior officers was established. A new building was erected especially for this new school, the plans of which were drawn up by Dr. Chandler himself. It was designed to accommodate 150 students, and was soon overflowing.

The school continued to prosper and its field to unfold and expand until what began as the School of Mines in a few basement rooms with twenty-four stu-

dents has now become a whole group of great technical schools (mines, engineering, chemistry, architecture and pure science) with many thousands of students and six splendid buildings and with a reputation which is not merely national, but international.

Thirty-three Years as Dean

Although at first appointed professor of geology, analytical and applied chemistry and assayer, Dr. Chandler soon was made dean of the school and became its leading figure, all-pervading geuius and chief driving force. For thirty-three years he served as dean, and of the many able and devoted men who have built their lives into this splendid institution, none have contributed so much as he. In 1897, when the university moved to its new site upon Morningside Heights, Prof. Chandler resigned his post as dean, but continued in charge of the department of chemistry as the "Mitchill professor of chemistry" until his retirement from active service, July 1, 1911. In the early days, he lectured upon all branches of chemistry, both theoretical and applied, but as the staff grew in numbers he transferred to his younger associates most of this, so that during the later years of his professorate his lectures were mainly upon general and industrial chemistry.

It was largely through Dr. Chandler's personal solicitation and influence that the Havemeyer family generously provided the funds for the erection of a splendid chemical building at the new site. Before drawing up the plans for this building, Dr. Chandler made a special trip to Europe for the purpose of examining the construction of the leading chemical laboratories there, with the result that Havemeyer Hall, when finally completed, embodied the best that was then known in regard to laboratory construction, and was universally regarded as the finest chemical laboratory in the United States.

Created Chemical Museum

The Chemical Museum of Columbia University is his own creation, begun and expanded through his indefatigable labors and personal generosity and, in recognition of this fact, the trustees have very appropriately named it the Chandler Chemical Museum. For many years it was unique, and is believed to be still the most complete of its kind in the world. There the visitor will get a very vivid impression of the extent to which our modern civilization is dependent upon the science of chemistry.

[Dr. Bogert here read the resignation of Prof. Chandler from the faculty in 1910 and several glowing tributes paid to him at that time. His work at the New York College of Pharmacy and the College of Physicians and Surgeons was briefly stated.]

As Author and Editor

As an author, Prof. Chandler has a long list of publications to his credit, embodying the results of research and invention, official reports, public addresses, sanitary regulations, analyses of waters, minerals, milk, etc., a survey of which shows at once the wide range of his interests and the versatility of his genius.

As an editor, he supplied for several years an American Supplement to the monthly edition of the *Chemical News* (of England); and, in July, 1870, in association with his brother, Prof. William H. Chandler, of Lehigh University, founded the *American Chemist*, and continued its publication until April, 1877, when it was given up, to make way for the *Journal of the American Chemical Society*. Another editorial task, and one which proved most laborious, was that of chemical editor for Johnson's Encyclopedia.

As Industrial Chemist

Chandler was one of America's first great industrial chemists, and aided and enriched almost every chemical industry which this country supported during the two decades following 1866.

His services have always been in demand by those great corporations whose manufacturing processes are based upon chemistry, for he has not only a thorough knowledge of that science, but also an alert mind stored with original and valuable ideas. He has been generally acknowledged to be the highest authority in this country in the field of industrial chemistry. While other able and eminent chemists have their single specialties, Chandler has been called a specialist in all branches, and is especially expert in sugar refining, petroleum refining, the manufacture of illuminating gas, photomechanical processes, and calico printing. He has served as chemist for the N. Y. Gas Co., and for the N. Y. Steam Sugar Refining Co., as consultant for the Standard Oil Co. and for various other great business interests.

He has no rival to the title of dean of the industrial chemists of the United States. Even now, at the ripe age of eighty-three, he is laboring daily in the offices of the Chemical Foundation, Inc., helping to prepare our country for the German chemical competition.

As Contributor to the Progress of Chemical Industry

One of his first and far-reaching contributions to the progress of chemical industry was the invention of the system of assay weights, as outlined in his article entitled "A New System of Assay Weights," which appeared in the American Supplement of the *Chemical News* of August, 1869. Although this system has been for years the one used by all assayers and metallurgists, it is safe to say that but few of them are aware of the fact that it was Chandler who introduced it, with the aid of Becker & Son, who manufactured the weights according to his specifications.

His observations and belief in the possibilities of the Castner process for the production of caustic soda by electrolyzing sodium chloride in a "tipping cell" with a flowing mercury cathode were communicated to the Matheson interests and they later, acting upon his advice, purchased the American patent rights and established in this country a great electrochemical industry at Niagara Falls, N. Y.

Water was one of the subjects to which he early turned his attention, and complete analyses were made of nearly all the famous Saratoga Springs waters. His first important commission was the investigation of boiler incrustations and feed waters for the New York Central R.R. Co., which investigation was begun in 1863 and completed in 1864 at the School of Mines.

It may be of interest also to note, in passing, a fact which is probably unfamiliar to many of this audience, namely, that it was due to Chandler's advice and urging that the firm of Eimer & Amend started their laboratory supply business in 1874. The founders of this firm were German apothecaries who were dissatisfied with the standard of purity of the American pharmaceutical products of that day and therefore began the

importation of alkaloids, etc. Chandler, who was personally acquainted with them through his connection with the College of Pharmacy, called at their office and urged them to extend this branch of their business and to include also the importation and manufacture of chemical apparatus. How great an assistance it has been to the cause of American chemistry to have had at hand the stores of fine chemicals and apparatus provided by this firm, it is difficult to over-estimate.

As Patent Litigation Expert

So much of his time was occupied in great patent suits that but little was left for investigation. I well recall his advice, when I asked him to give me some guiding principles in serving as chemical expert in such litigation. His answer was brief and to the point: "Know your lesson. Tell the truth. Don't be afraid to say 'I don't know.'"

The most famous suit in which he participated was that brought in the interest of the widow and assignees of the Rev. Hannibal Goodwin, an Episcopalian minister of Newark, N. J., and an amateur photographer, who was the first successful inventor of a flexible nitrocellulose film for the kodak camera and for moving picture negatives and positives. Goodwin's opponents kept him in the Patent Office ten years before he could get his patent, when he died. Thirteen years of most strenuous litigation was required to win against the infringer. Rather than have a court investigator examine the books to determine the proper award, the defendant settled with the plaintiffs by the payment of $5,000,000, which is believed to be the largest amount ever secured in a patent suit.

Other noteworthy suits were the first synthetic coal-tar color cases, of which there were five concerned with artificial alizarin, and others later which had to do with the Roussin patents, owned by Poirier & Co., of Paris, for the azo dyes obtained by diazotizing sulphanilic or naphthionic acid and coupling with suitable amines, amides or phenols; but to review even briefly the many notable suits in which he has been engaged would take an entire evening, as they include subjects in almost every branch of chemical industry.

As Builder of American Chemical Organizations

As a builder of American chemical organizations, Dr. Chandler has played a notable rôle.

He was president of the convention of chemists which gathered at the grave of Dr. Joseph Priestley, Northumberland, Pa., July 31 and Aug. 1, 1874, to celebrate the centennial of chemistry, and where the first seeds were sown of what was later to become the largest and most powerful national organization of chemists the world has ever known, and of which Chandler has been twice president and many times a director—the American Chemical Society.

The founding of this society is described in the issue of the *American Chemist* of May, 1876. After the centennial meeting in 1874, the project of establishing a chemical society was often discussed by many of the New York chemists, and it was finally decided to call a meeting for the purpose. As was to be expected, Chandler at once became the recognized leader in the movement and, under date of Jan. 22, 1876, a self-constituted committee, of which he was the guiding genius, sent out a circular letter to all chemists in New York and vicinity inviting co-operation in the formation of a local chemical society. Emboldened by the number of favorable replies received to this communication, the same committee, on March 22, 1878, distributed a second circular letter suggesting the desirability of organizing a national instead of a local chemical society, and submitting a tentative draft of a constitution and bylaws for an American Chemical Society. So many approved the proposal that a call for an organization meeting was issued on March 27, 1876, and on April 6, 1876, this meeting was held in the rooms of the New York College of Pharmacy, with thirty-five chemists in attendance and with Dr. Chandler as presiding officer, and the American Chemical Society was born.

There were, to be sure, some conservative and timid souls who feared for the success of the venture, but they were in the minority fortunately, and the progressives rallied in overwhelming numbers to Chandler's support. Among the latter was another of the great builders of American chemical industry, a former president of this society, Dr. William H. Nichols, who at that time uttered the following prophecy: "We do not come here expecting to find a society ready formed, with a library and a fine building; those will come in time. There is enough enthusiasm among the chemists to give us them by and by." Two of the men largely responsible for the fulfillment of that prophecy were Chandler and Nichols.

Chandler is thus the father of the American Chemical Society. The handful of members has grown to over 13,000, and this vast membership is drawn not only from our own land but from all quarters of the globe. The few hundred dollars income of those days has swelled to an annual budget of close to a quarter of a million. There are more local sections now than there were chemists at the organization meeting forty-four years ago. To take the place of the *American Chemist*, the society publishes three great journals, which circulate among all the civilized nations of the world.

It is also just to refer to Dr. Chandler as the father of the Chemists' Club, for, although he was not the originator of the movement which led finally to its establishment, he had always spoken in favor of such an affiliation of our New York chemists, and he was the unanimous choice for the club's first president. Without his wise and experienced guidance, his unquenchable optimism, and his financial assistance, the club would have had a hard struggle for existence. He has been its chief reliance through good and bad weather.

Other Honors Received

In addition to the honors already recorded, the University of Göttingen, upon the fiftieth anniversary of his Ph.D. degree, officially renewed this degree and sent him a parchment to that effect.

He received the M.D. from the University of New York in 1873, and the LL.D. from Union College the same year. In 1900, Oxford University conferred upon him its D.Sc. This was indeed a signal distinction, as the only previous recipient of this honorary degree from Oxford had been the Prince of Wales. Chandler was thus the first scientist upon whom it was conferred. In 1911, Columbia also awarded its LL.D.

He is a member of the National Academy of Sciences, of practically all the leading chemical societies both here and in Europe, and of many other scientific, learned, and philanthropic organizations.

On April 30, 1910, a huge banquet was given in his honor by the chemists of America and a bronze bust of life size was presented to Columbia University. It is

an excellent likeness, and now is housed in Havemeyer Hall where all may see it.

When the Society of Chemical Industry decided to recognize its large and influential American Section, and to draw closer the bonds uniting the two nations, it made inquiry as to whether there was any one American chemist who, by the common consent of his colleagues and in virtue of his achievements, might properly be regarded as first among our industrial chemists. There was no question that Chandler was, and had been for many years, the leading figure in this field, and he therefore received the unprecedented compliment of election to the presidency of this great international society, being its first American president, and thus joined the group of distinguished men who had held that high office previously.

The Medalist

Were Sir William Perkin himself alive, I am sure that nothing would have given him more pleasure than to have seen the Perkin medal presented to his dear friend Chandler, for when Sir William and his family last visited our shores, the Chandler home was their home.

Perkin's contribution to applied chemistry was the founding of a great industry, which has had a most marvellous development and by which civilization has been brilliantly advanced. Chandler's greatest contributions have been in the most important chemical industry of all—the making not merely of chemists, but of men, and in applying his chemical knowledge in the service of mankind to protect the health of the community and to save human life.

Thousands of lives and an immense amount of suffering are saved annually as the direct benefit of the sanitary reforms which he initiated. Other thousands of lives have been so profoundly impressed by his noble example and inspiring altruism that the world is a better and a happier place to live in. The bounds of such an influence are far-reaching indeed, and its duration outruns the lives of many generations.

No student ever attended his courses without being immediately struck with the fact that here was a man of lofty ideals and noble aims who was honestly and unwearyingly trying to be of service to his day and generation, and whose actuating impulse might not improbably have been expressed somewhat as follows:

> If men can say—if they but can—
> "He did his best; he played the man;
> His way was straight; his soul was clean;
> His failings not unkind, nor mean;
> He loved his fellow men and tried
> To help them"—I'll be satisfied.

I am sure that I speak not alone for myself, but also for this entire gathering and for all who know him, when I say that in our judgment he has consistently lived up to that standard throughout his long and useful life, and that he has achieved a wonderful measure of success in the sense of that work as defined by Dr. William H. Nichols, who regards it "not as the acquisition of property but the making the most of oneself."

The Presentation

The medal is awarded this year to Dr. Chandler because, in the opinion of the jury of award, in addition to his many valuable contributions to other branches of applied chemistry, he has made such notable advances in the great fields mentioned that he has placed the entire world in his debt and brought added prestige and dignity to the profession of which he is such a conspicuous ornament.

And now, my dear teacher, guide and friend, I cannot tell you how happy I am to be the agent selected to present this beautiful medal to you—I who have received so many favors at your hands, and who would not exchange for any amount of chemical knowledge the inspiration and encouragement derived from your example of a life worth while, and a character, like this medal, of pure gold.

May it be to you a token not only of our high appreciation of your brilliant scientific achievements, but also of our deep and abiding affection! May it bring to you and to those dear to you immeasurable happiness, and may you long be spared to continue your useful work and to be the friend and guide of those setting out on life's journey.

> For, after all, life is a highway,
> And its milestones are the years,
> And now and then there's a tollgate
> Where we buy our way with tears.
>
> It's a hard road and a rough road,
> And it stretches steep and far,
> But it leads at last to a haven of rest
> Where peace and happiness are.

Address of Acceptance

By Charles F. Chandler

Mr. Chairman, Ladies and Brother Chemists: I never was more surprised than when I was notified that the Medal Committee representing the different societies interested in the Perkin medal had awarded it to me. I had never really considered myself eligible, as I supposed the medal was intended particularly for discoverers and inventors of important processes in industrial chemistry. Nevertheless, I accept it with gratitude as an expression of appreciation and affection on the part of my brother chemists.

The selection of Milton C. Whitaker and Marston F. Bogert to speak for me this evening is most gratifying. There are no two men in the chemical profession for whose attainments I have a greater respect or for whose personal qualities I have a greater affection.

After having had the pleasure of presenting this most valued token of appreciation to eleven distinguished chemists, it seems odd to stand tonight in a position of the receiver instead of the giver. It is, however, eminently appropriate that Dr. Bogert should take my place on this occasion, as it falls to the lot of the senior available ex-president of the Society of Chemical Industry residing in the United States to make the presentation.

I happen to have been the first to receive this honor from the Society, there never before having been a foreign president. The experiment must have been satisfactory, as it was soon followed by the election of Dr. W. H. Nichols, then Prof. Ira Remsen and finally by Dr. Bogert. Dr. Nichols and Dr. Remsen are not available tonight, and so the duty falls upon Dr. Bogert as the representative of the Society of Chemical Industry.

I think that there was another reason for selecting Dr. Bogert to make the presentation address. He has had experience at the banquet of the chemists, April 30, 1910, and conspicuously demonstrated his ability to say the kindest and most flattering things about his "old professor."

Dr. Bogert has given you such a comprehensive account of my life and experiences, it is hardly necessary

for me to go very deeply into the subject. I will therefore select only a few incidents which may possibly interest you.

What Determined Dr. Chandler's Career

When I was about fourteen years of age and attending the New Bedford High School, the incident occurred which settled my career for life. There was a young instructor who had a class in chemistry which I attended. He made the subject so interesting that I decided that I must be a chemist. I had a little workshop which I promptly converted into a chemical laboratory, had the tinsmith make me a gas holder and amused my three or four intimate playmates by making oxygen, hydrogen, olefiant gas and various other experiments. The impression which this teacher made upon me has lasted ever since. Two or three years ago I had occasion to give a lecture in New Bedford and I opened it by recalling my school days and I enlarged upon the influence which this young teacher had exerted upon my life. I was subsequently informed that he died while still very young. It was in 1851-52 that I attended his courses. A few days after my lecture I received the most touching letter from his aged widow, who is still living and had been told what I had said of her husband. Her letter brought tears into my eyes.

In 1853 I entered the chemical laboratory of the Lawrence Scientific School and spent a year under the instruction of Prof. Eben N. Hosford, a most charming man. Here I pursued a well-arranged course of instruction in qualitative and quantitative analysis. Here another incident occurred which had a profound influence on my subsequent life. Two strangers visited the laboratory one day and we half dozen young chemists were introduced to them. One was Prof. Josiah D. Whitney, the eminent mining engineer and geologist who five or six years afterward became a very intimate friend of mine; the other was Dr. Charles A. Joy, who had just been appointed professor of chemistry to take charge of the new laboratory at Union College, Schenectady. Prof. Joy told us that he had just returned after a course of four years' study in Germany in the laboratories of Friedrich Wöhler and Heinrich Rose. I subsequently wrote him for further information on the subject of studying in Germany and received a full and enthusiastic account of the advantages not only of studying in Germany but of studying with these particularly distinguished chemists. It resulted in my spending my next year in the University of Göttingen. I was fortunate in being placed at once by Prof. Wöhler in the laboratory for advanced students, which was under his personal direction. I took several courses of lectures and practical instruction, not only in chemistry but in physics, botany and mineralogy.

Companionship With Celebrated Professors

We had a large colony of Americans in Göttingen during the year, most of whom were studying chemistry and some of whom have subsequently held most important positions in the United States. As I was the youngest of them all, it was a great privilege for me to enjoy the companionship which was quite intimate in that small town with such men. One of them, Prof. Goodwin, was a Harvard professor of Greek; another, Prof. Harkness, who was there with his wife, was professor of Greek in Brown University. At the end of the year Prof. Wöhler, who had been a father to me and had invited me frequently to his house, induced Prof. Heinrich Rose to take me into his private laboratory as an assistant, where I spent a year working in the same room with him. He, too, was a father to me, and invited me frequently to his house. His brother, Gustave, with whom I studied mineralogy, was equally friendly. I attended several courses of lectures in general chemistry by Heinrich Rose; industrial chemistry and physics by Prof. Magnus and physics by Prof. Dove. At the houses of the two Roses I used to meet some of the most distinguished scientists in Berlin, particularly Poggendorf and Ehrenberg, the father of microscopy. I also had the great pleasure while in Berlin of spending a couple of hours with Baron von Humboldt in the Royal Palace in Potsdam. Both Wöhler and Rose gave me the most interesting material to work upon in their laboratories either for the purpose of preparing a constituent in some quantity or for making accurate analyses of the minerals. For example, I worked upon the following materials; that is, minerals containing them when the mineral itself is not mentioned: Selenium; tellurium; lithia; thoria; yttria; molybdic acid; tungstic acid; cerite; columbite; tantalite; sarmaskite and yttrotantalite, and other more common materials.

At the end of my second year in Germany, I was asked to put the work that I had performed in the laboratories of Wöhler and Rose into the form of a dissertation, which I did. It was accepted and printed in Göttingen at the University Press in 1856 and I received without examination, in consequence, my degrees of A.M. and Ph.D., or, as they call it in Germany, Dr.Phil.

Begins Professional Life at Union College

On my return to America late in the summer of 1856, I found an invitation awaiting me from Prof. Joy inviting me to come to Union College and accept the position of assistant in the laboratory. This invitation I promptly accepted and on Jan. 9, 1857, I began my professional life. I felt under such obligations to Prof. Joy for having directed me to Europe that I did everything I could in the laboratory for his convenience and comfort. In four months he was called to Columbia College and left at once to take the position. Fortunately for me, the venerable president of Union College, the Rev. Eliphalet Nott, had so much confidence in my abilities that he offered, if I could lecture to the senior class, to put me in charge of the chemical department and give me the title of professor when I was old enough to merit it. I remained at Union College until the fall of 1864; was married, given a house which had formerly been occupied by President Nott and had established courses of lectures in the different branches of chemistry, including agricultural chemistry, and in mineralogy and geology.

Established Columbia School of Mines

Then by a happy accident I was invited by Prof. Eggleston to join him and General Francis Vinton in establishing the School of Mines at Columbia College, which has proved such a great success. The most fortunate circumstance in connection with this embryo school of mines was the fact that we had no salaries. My friends ridiculed and lamented what they considered my rashness in acccepting what seemed such an unpromising appointment. But it turned out a great success. The school not only grew rapidly into a large enterprise but it gave a most powerful impetus to the growth and development of Columbia College, which

although it had been in existence for more than 100 years had only 155 students, almost exclusively residents of New York City. This school of mines, which quickly became a school of every variety of engineering and chemistry, drew students from all over the United States, and spread the name and reputation of Columbia College everywhere, while the graduates, particularly the mining engineers, carried the name of Columbia to Australia, New Zealand, South Africa, South America and Mexico.

If I should continue in this vein to tell you all of my experiences during the sixty-four years that have elapsed since I received my degrees, I should be obliged to keep you here for hours.

Starting at Columbia with no salary at all, with only the expectation of receiving one-third of the fees that might be paid by any student who might attend, we were naturally permitted to take any outside work that was congenial which did not interfere with our duties in the School of Mines. I was soon enabled to take advantage of this privilege by giving afternoon lectures from 5 to 6 at the College of Physicians and Surgeons and evening lectures at the College of Pharmacy and also to accept invitations for professional work of different kinds.

Work for Excise Board

One of the most promising invitations I received came to me from the Metropolitan Board of Excise. The members of this board, not being chemists, were imbued with the idea that there was an enormous amount of adulterated alcoholic beverages in New York and as they had a very high license and a million dollars to their credit in the bank, they started out to put a stop to this adulteration and I was invited to act as their expert to analyze the samples and to appear in the courts as their representative. When they inquired of me how much I would demand for making these analyses and appearing in court, I told them it would depend upon the number they were likely to have. They told me that there were 8,000 liquor dealers and they would certainly average three samples each, so I agreed to a fee of $20 for each case, no matter how troublesome it might be. This they considered reasonable, and when I figured it up I saw a prospective $480,000. They promptly sent me forty samples, upon which I exhausted every possible chemical test. These samples came from Mulberry Bend and other localities where the poorest liquors are probably dispensed. They consisted of brandies, whiskeys, rums and gins. Some were of very good quality, some were not so good, but not a single one contained any objectionable constituent; not one was adulterated. I must confess that I was not much surprised, because I had had some previous experience in making such analyses, especially for the Vermont State Liquor Agency, and I knew that the newspaper stories of adulterated and poisonous liquors were without foundation. I received a check for $800 according to contract and never another sample for analysis, and I charged $479,200 to profit and loss.

Kerosene Industry

I have been told that some members of your committee were of the opinion that my work in putting an end to kerosene accidents and stabilizing the manufacture and the quality of kerosene was my most important work, and I will give you a little account of that and then bring my remarks to a close.

In the year ended Oct. 31, 1869, there were ninety-eight fires caused by kerosene accidents in New York City, and thirty-one in Brooklyn. There were fifty-two persons burned to death in New York City from the same cause, mostly women and children. It was generally supposed that these accidents were due to the fact that kerosene consisted of hydrocarbons, similar to those of camphene and burning fluid, which were known to be inherently dangerous and which could not be made safe. When this matter was called to my attention, I said at once, "Kerosene can be made safe," and took up the investigation of the subject at once.

Manufacturers of kerosene and chemists had decided that all that was necessary to make the oil safe was to separate the lighter oils benzine and gasoline. And I believe that they did so. A standard of quality had been adopted by them. The kerosene oil must not evolve combustible vapor at 100 deg. F., and must not take fire below a temperature of 110 deg. F. On purchasing seventy-eight samples in shops in the city, I found that one sample was pure naphtha, while every one of the seventy-eight others was adulterated with naphtha. Not one of them came up to the standard of the manufacturers. I had a sample of real kerosene for comparison which I obtained from the works of a friend of mine, Dawner of Boston, which had a flash point of 109 deg. F. and a burning point of 128 deg.

Report on Kerosene Spread Broadcast

Just as I finished my experiments there was a terrible accident in New York in which a mother and child were burned to death. I sat up all night and wrote my report. It was manifolded at the Board of Health and given to all the papers, in which it was printed in full, and later published all over the country. The Board of Health of New Orleans had it printed and left a copy at every door. It was quoted in Berlin and in Rome. On Jan. 21 a supplementary report was made showing the temperatures reached in twenty-three house lamps, of glass and of brass, of different sizes, after periods from 1 to 7 hr. After 1 hr. the highest was in a brass lamp, 100 deg. F., the lowest in a glass lamp, 77 deg. F. After 7 hr. the highest was in the same brass lamp, 91 deg. F., the lowest in a glass lamp, 78 deg. F.

The investigations were continued, and later in the year a third report was made containing the following additional results, with a new collection of samples from retail shops in New York City:

	Samples
1. Safe oils complying with requirements	21
2. Dangerous oils, flash point below 100°	280
3. Still more dangerous, flash point below 100°, burning point below 110°	306
4. Pure naphtha	29
Total number of samples	636

A fourth investigation was made and reported, March 18, 1891, of a much more elaborate character which covered 110 printed pages. This was published and Charles Pratt asked permission to print 10,000 copies, placing an advertisement on the cover of his famous extra safe oil, known as Pratt's Astral Oil, which flashed at 125 deg., and burned at 138 deg. F. Permission was cheerfully granted.

The board adopted a sanitary ordinance limiting the sale of oil having a flash point below 100 deg. or a burning point below 110 deg., and appointed inspectors and equipped a testing laboratory, and before long kerosene accidents became very rare, and when they did occur generally resulted from kindling the fire with kerosene

or some other kind of criminal carelessness. Not long after this I was engaged, in company with Prof. Silliman, to act as an expert witness in a suit brought by infringers by Downer & Co. of Boston. This company had worked on oils obtained from the destructive distillation of coal, and also on petroleum. By employing a special process they produced, among other products, two specially high test oils: Downer's Standard Kerosene, flash point 115 deg., burning point 128 deg.; and Downer's Mineral Sperm, flash point 262 deg., burning point 300 deg.

Combustion

I will quote here a few paragraphs from a lecture on "Combustion" which I gave before the American Institute Jan. 5, 1872, immediately after the great fire in Brooklyn which was so disastrous to life.

"Naphtha is not explosive; vapor of naphtha is not explosive; it is a mixture of naphtha vapor and air, in certain definite proportions, which is explosive. If, in experimenting, we do not hit the proper proportions, we fail to produce an explosion. Any oil that will emit an inflammable vapor at any temperature below 100 deg. F. is liable to form explosive mixtures of vapor and air, and is dangerous. I know of no process by which the lighter products of petroleum, gasoline, naphtha and benzine can be made non-explosive or safe, nor do I believe that there is any such process. If any oil takes fire at ordinary temperatures, or below 110 deg. F., it is proof positive that it is dangerous, and no argument or experiment can prove anything to the contrary.

"This coat on its iron frame is a good representation for our purposes of a victim to kerosene. I will drench him with good kerosene; you see now that though I hold a candle to him he is in no danger. I will now throw a little of Smith's 'Safety Oil' upon him; you see the moment the candle is brought near him he bursts into flames. I will save the poor wretch from a painful death by bringing the Babcock Fire Extinguisher to bear upon him. I have put him out; but were he human his days would be numbered, as a painful death would be sure to follow such frightful burns as those he has suffered from Mr. Smith's safety oil. It is said, and I believe with truth, that the burning of a square foot of the human body is sure to cause death.

"Before leaving this portion of the subject, I want to show you how safe it is possible to make petroleum oil. I have here a pail containing 3 gal. of Downer's 'Mineral Sperm Oil.' Into it I will plunge this mass of cotton waste till it becomes saturated with the oil; now as I raise it you see it is dripping with the oil. On holding the candle to the oily mass you see I have considerable difficulty in setting it on fire, but by heating it in one spot I shall finally heat a portion to a temperature above 300 deg. F., its burning point, when it will take fire. Now you see I have succeeded in starting combustion, and the burning oil quickly heats the rest of the mass till we have a flame 10 or 15 ft. high. You need not feel alarmed, for I have the flames entirely under my control. I will now plunge the burning mass into the pail of oil; you see it is at once extinguished. The 'Mineral Sperm' is actually a fire extinguisher.

"But this oil will stand a much more severe test. Here we have a large pan of oil on a water bath. These two large alcohol lamps have raised the water to boiling; you see the steam escaping from this vent; the oil is at 212 deg. F., 112 deg. above the standard flashing point and 102 deg. above the standard burning point of safe oil. Yet you now see that this mass of cotton waste which was saturated with the oil and was but a moment ago wrapped in flames, is now quietly extinguished. The 'Mineral Sperm' is a fire extinguisher even when heated to 212 deg. F. Am I wrong in saying it is practically as safe as whale oil?"

Work on Petroleum Oils

The Standard Oil Co., recently organized, manifested a great interest in my work on kerosene, and employed me as an expert in law suits, brought against them by persons who erroneously believed them using their patents, generally worthless, without their consent. Some years later when what was known as "Ohio oil" was obtained in Ohio, Indiana and Illinois in considerable quantities, the company received word from its German associates that the German Government had been informed by rivals that while the Standard Oil Co. was supplying the American market with the superfine Pennsylvania oil, it was sending to Germany the poor, offensive "Ohio oil." In consequence, the Imperial Government was about to permanently forbid the importation of this poor oil into Germany. A high officer of the Standard Oil Co. came to me and begged me to go at once to Germany and convince the German Government that the Ohio oil which his company exported was first purified by the process invented by Herman Frasch. This was one of the inventions for which your committee, a few years ago, awarded to Frasch the Perkin medal.

President Low granted me a leave of absence, and I immediately visited the great works erected at Whiting, Ind., for the special treatment of Ohio oil by the Frasch process. The impurities which had rendered the oil and all its products so offensive were certain compounds of sulphur, of which element the oil contained about 1 per cent. Frasch's process consisted in first dividing the crude oil by distillation into three fractions:

1. Lighter constituents, gasoline, naphtha and benzine.
2. Medium oil for lamps.
3. Heavy oil for lubricating and paraffine.

These three fractions were then entirely freed from the sulphur compounds by distillation in huge stills, while mixed with large quantities of oxide of copper, with constant stirring. The effect was magical. Not a trace of the offensive odor was retained by either of the products.

I met at the Whiting works the chemist in charge, Dr. William M. Burton, a Heidelberg graduate. He showed me everything and answered every question. When I told him that I was going to Berlin to explain the situation, a longing look overspread his face, and he remarked that he had not been in Germany since he graduated. I caught the look and asked him if he would like to go with me. He replied that he would give anything to go. I found no difficulty in persuading the company to give him a leave of absence, and so I had a most agreeable and useful companion.

Before I sailed I visited the works at Olean, N. Y., at Philadelphia, and at Brooklyn. So there was nothing in the treatment of petroleum that was not imparted to me. We went off together. It seemed wise, before we called upon the representatives of the government, to

visit and satisfy the men who would be most likely to be consulted by them. So after visiting the representatives of the Standard company in either Bremen or Hamburg, I have forgotten which, we went to Karlsruhe and explained the whole matter to Dr. Engler, the German expert on petroleum, giving him samples of the Ohio kerosene, and explaining how he could prove the absence of sulphur, if the entire freedom from offensive smell did not satisfy him.

Convinces German Government of Purity of Ohio Oil

Then we went to Zurich and explained the matter of Dr. Lunge, the distinguished industrial chemist. On arriving in Berlin, we adopted the same tactics with the Imperial Health Department, with the same success. With all these parties I had enjoyed an acquaintance for some years, so we were cordially received and our statements readily accepted. An hour spent with Count Posidowski, the Imperial Minister of the Interior, settled the business.

A few years later I was sent to Germany to again try and prevent the threatened establishment of an extra high standard for all imported oils, to be considerably above "100 deg. flash and 110 deg. burning." This time I did not have the company of Dr. Burton. As before, I first went to Karlsruhe to argue the matter with Dr. Engler, but to my discomfort I found that he was in the Austrian Tyrol, near the glaciers. There was nothing to be done but to follow him, so I crossed Lake Constance and took the train for Vienna, leaving it the next morning at Bludence. Here I hired a man to drive me to my destination, which was a day's journey. At noon we stopped at a cross-road village for lunch and to change horses. After eating my simple lunch of "Butterbrod" and "Schweitzerkäse" and drinking my "Bayerisch." I started out to see if there was anything interesting in the village. Strolling into the country store, I inquired of the proprietor in German if he sold petroleum. He replied, "Yes, indeed." I inquired what kind and he said "Amerikanisches." "Is it not much more expensive than that from the neighboring wells in Rumania and Galicia?" "It is, indeed," he replied, "but it is so much purer; it will burn in any lamp without smoking, while the other oils will burn only in a special lamp." He assured me that the peasants willingly paid the extra price. This interview gave me my trump card. Engler saw the point at once, and so did the Imperial Board of Health at Berlin, and so did Count Posidowski. I made it clear to them all that if they raised unnecessarily the standard of oil to be permitted to enter Germany, the only result would be that the Standard Oil Co. would get 50 gal. of such oil out of 100 crude, while they were getting 60 at that time. It would have no real advantage, while the German people would pay as much for the 50 gal. as they were paying for the 60 gal. He saw the point and that was the end of it.

Some years later a bill was introduced in Parliament to accomplish the same result in order to help the Scotch manufacturers, who made a comparatively small amount of kerosene from the Bog Head mineral. I was in Paris at the time and in response to a telegram from the Standard company I went before a parliamentary committee and made the same argument. A member from the Bog Head district, who was working for the bill, had a copy of my last report of 1871 before him, identified me as the author, and then asked me if I had not intimated therein that "the higher the flash point, the safer the oil." I replied that I had, but at that time we had not had as much experience as at present. Time had shown that "100 deg. flash" was sufficient to insure safety, and that that grade of oil was generally used in the United States and exported all over the world, and that lamp accidents were very rare.

Further I reminded him of an English nobleman who lost his life by the explosion of an extra high test oil, because the oil evolved just enough vapor to make an explosive mixture with the air in the lamp, while the 100 deg. flash evolved enough vapor to render the air in the lamp non-explosive.

Several distinguished English chemists, Sir Henry Roscoe, Sir Boverton Redwood and others gave similar testimony, and the bill never passed the committee.

I should like to add here that my friend Dr. Burton invented a most successful process for breaking up heavy oils into gasoline substitute for motors. He distills and condenses under a pressure of 90 lb., the heat required being sufficient to break up the molecules of the heavier oils into smaller molecules which constitute the lighter and more volatile gasoline, benzine and naphtha. There are now in use 1,000 sets of his stills and condensers, 240 of them at Whiting.

The Metropolitan Health Department of New York

In 1867 Dr. Elias Harris of the New York Health Department came to see me and told me that the Commissioners were not chemists and did not realize how much chemistry had to do with the public health and did not care to devote any portion of their income to this subject. He asked me if I would be willing to do some work for the department without charge. I promptly accepted his invitation and interested myself at once in a great variety of subjects, most of which I shall have to omit discussing.

Water

There are two or three matters, however, which interested me very much; one of these was water. I began analyzing the Croton and Ridgewood waters every week during the three or four summer months, and I continued for several years, either myself or when I became president of the Health Department through Prof. Waller, to keep informed with regard to the water supply of these two cities. I found that these waters were then and have been ever since among the purest waters supplied to any cities in the world. I do not believe that a case of sickness was ever caused by either one of them. General Green, who was at one time the engineer of the Croton aqueduct, was so interested in my work that he had me appointed consulting chemist for the department, and took me all over the Croton watershed that I might become familiar with the sources of the water. It is a source of constant regret to me that ill-informed persons, even physicians, are so ignorant on this subject that they advise families not to drink the Croton water unless it has been filtered or boiled or both, and the result is that millions of dollars are spent in New York every year for bottled waters, not only in families who can ill afford the expense, but in downtown business offices. During the fifty-six years that I have lived in New York, I have used the Croton water in my family without filtering or boiling, and never has anything occurred to lead me to suppose that the water was not

perfectly satisfactory and wholesome in every respect. Another phase of the water question occupied my attention for a year when at the request of the New York Central R. R. Co. I studied the subject of boiler corrosion in locomotives, boiler incrustations and feed water. I began this work at Union College and completed it in the School of Mines, publishing my results. I analyzed numerous specimens of incrustations, finding that some of them consisted of carbonate of lime; others of a mixture of carbonates of lime and magnesia; others of sulphate of lime. I also investigated the different brands of boiler medicines, most of which were frauds and the one which seemed to be an excellent one was sold to the railroads for five times what it cost to make, and the engineers couldn't bring their trains in on time unless this particular medicine was supplied by a particular firm. In the end, I analyzed all the feed waters employed on the road between Albany, Buffalo and Niagara Falls, classified them as to quality, indicating those that were too bad ever to be used and causing the water stations to be abandoned, and directing the best choice to be made among the others.

Hudson River Water

I was called upon by the Water Commissioner of Albany to investigate the waters of the Hudson River, to ascertain whether it would be safe to take the water above Albany and below Troy to supply the city, as they had found it almost impossible to procure an adequate source of supply within reasonable distance and at such cost as the city could afford to pay. I took up this investigation with great doubts of the fitness of this water for the city supply. I made the most careful investigations and analyses and was surprised to find that there was no reason why this water could not be used in the city of Albany. I sent in my report in 1872, stating my conclusions, with a special discussion of the destruction of the sewage contamination of large rivers caused by dissolved oxygen. I had obtained a great deal of information on this subject from the annual reports of the British Water Commissioner. The report was published and indignation meetings were held in Albany and no end of abuse was poured upon my head. The Water Commissioners were very sensible men, however. They said there was no sense in abusing Chandler; disprove his facts, meet his arguments or keep quiet. My facts could not be disproved and my arguments could not be met and consequently the Water Commissioners put up the pumping station, supplied the water to Albany, and in a short time the Health Officer of Albany informed me that the water was entirely wholesome and satisfactory.

In 1885 it became necessary to increase considerably the pumping facilities above Albany, and the Water Commissioners wrote me, calling attention to the fact that since I made my first investigation and report in 1872 bacteria had become fashionable and were now supposed to be terrible creatures capable of producing all kinds of diseases, and whether I cared to revise the opinion which I gave them thirteen years before. It happened that I was quite familiar with what had been published with regard to bacteria, having quite a library on the subject and having had occasion to make myself specially familiar with them in order to prepare an article on fermentation for Johnson's encyclopedia about 1874, so I wrote the second report on the waters of the Hudson River, which was published in Albany in 1885, containing a discussion of possible bacterial contamination of water.

Fourteen years ago while in Europe I was cabled to look up the ozone treatment of city waters. Accordingly, I visited Berlin, Paderborn and Paris, where experiments had been carried on. At Paderborn the process was in full operation, although the water supply was entirely above suspicion. The water descended slowly through a wide circular cylinder, while the ozonized air bubbled up through it. The effect was marvelous. The ozone seemed to destroy the organic matter, which though minute, was sufficient to conceal the true color of the water, for when the treated water was poured into a large snow white vat, it was very distinctly blue.

Saratoga Waters

In the early years of my residence at Union College, I became interested in the Saratoga waters. I found a great diversity of opinion as to the nature of these waters, some local physicians telling their patients that there was such a great difference in the waters that it was not safe for them to drink them except after the physician had carefully diagnosed their cases; had directed them as to which waters they should imbibe, what quantities of each, and at what times of day. The owners of the Star Spring employed me to make a careful analysis of their water and soon it became the fashion to have the waters analyzed by me, as the waters contain a great variety of constituents, including small quantities of iodine, bromine, baryta and lithia, etc. I had to charge a good round figure, which those who could afford it cheerfully paid, and as I was extremely anxious to analyze all the waters for those who could not afford to pay my fee, I made the analyses gratuitously, including springs and artesian wells. I analyzed about a dozen different springs in Saratoga and three at Balston. Instead of the waters differing from one another, I found that they all contained the same constituents, counting out one or two sulphur waters in out of the way places which I never took the trouble to analyze. The total amount of solids varied from a minimum of 302 grains in one United States gallon to 1,184 grains, the latter being the amount in the Balston artesian lithia well, which was bored over 600 ft. There is an interesting story about the High Rock Spring at Saratoga. It is the oldest known spring there and it consists of a volcano-shaped rock about 4 ft. above the level of the surrounding ground with a hole or crater in the center supposed at that time to be of almost unknown depth. This hole had a diameter at the top or mouth of 8 or 10 in. and the water rose to within about a foot of the top. Saratoga was first visited by a white man when Sir William Johnson went there in 1767. He was told by the Indians that according to their traditions the water formerly rose and overflowed regularly, continuously, but not within their recollection. This must evidently have been the case, for the High Rock is composed of tufa, carbonate of lime and contains the impressions of leaves and the shells of snails here and there. It had evidently been formed gradually by a deposition of carbonate of lime from the water, which is a common occurrence with this class of waters. After a time during my association with Saratoga, this spring changed hands and the enterprising purchaser decided to make the water resume its old habit of overflowing

the rock. In order to do this, he had oblique holes drilled on different sides around the edges of the rock toward the center. He then introduced wedges and succeeded in detaching the rock from its base. He then put chains underneath and hoisted it off one side. Then they enlarged the hole up through which the water came and went down expecting to find some leak which had prevented the water from rising any higher, and which they intended to close. They found beneath the High Rock a layer of tufa 7 ft. thick, including some muck, below that they found 2 ft. of tufa clean, below that 1 ft. of muck and below that again 3 ft. of tufa. Just below the rock itself they found four well preserved logs put crosswise at right angles to make a curb for the spring, which must have been placed there before the High Rock was formed, and, finally, at a depth of 17 ft. they found a considerable quantity of half-burned embers and charcoal, showing that at some previous time visitors had made fires before that 17 ft. of material had been deposited.

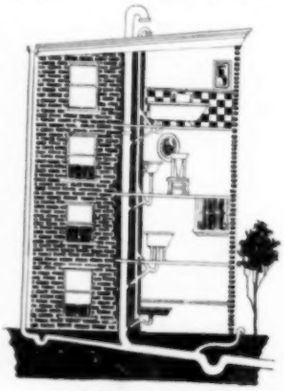
An enterprising citizen of Saratoga was very anxious to ascertain when those fires had been made, and remembering that the botanist ascertained the age of a tree by making a cross-section of the stem and counting the lines or rings from the center of the circumference ascertained the number of years it had been growing. He took a piece of the High Rock, smoothed it against a grindstone and found it showed 81 lines to the inch, so he said it must have taken 3,840 yr. to form. The following table shows his figuring:

THE HIGH ROCK

	Yr.
The High Rock 4 ft.—81 lines to in.	3,840
Muck and tufa 7 ft.	400
Tufa 2 ft.—25 lines to in.	600
Muck	130
Tufa 3 ft.	900
Total	5,870

According to his education, the world had only existed 4,004 years before the Christian era, and 1,870 years after the Christian era, or 5,874 years in all. As the fire was made 5,870 yr. in the past, it was made 4 yr. after the creation. Consequently, there was no one living on the face of the earth excepting Adam, and he was four years old. I hope you will pardon my frivolity in presenting this ridiculous proposition to you, but it went the rounds in Saratoga.

There is one other interesting matter connected with the Saratoga Springs. Some years ago a sanitarium near the Hathorn Spring set up a pump, and drew large quantities of water from a tube of some depth, with the result that the Hathorn well was very seriously affected. A law suit resulted in which my testimony and that of others was taken in favor of Hathorn, with the result that the sanitarium was enjoined. At or about the same time, a company began to bore numerous wells some little distance from the springs, introduce steam pumps, commercialize the carbonic acid gas, and permit the water to run to waste. In a short time the springs began to show the disastrous effects. The waters no longer spouted from the spouting springs, the others no longer came to the surface, and pumping had to be resorted to. In addition to this the diminished pressure of water in the springs permitted fresh water to permeate and dilute them.



CHANDLER PLUMBING SYSTEM

Again I was called as an expert, and testified to the ruinous effect of this pumping. The company produced experts who declared that it was absolutely impossible for this pumping to have any effect whatever on the springs, and that the falling off of the springs must be due to natural causes. The judge, however, was a second Solomon. He directed the defendants to stop pumping for 48 hr. to decide the question, and ordered the sheriff to see that the order was obeyed. Within 24 hr. the whole town gathered around the Hathorn Spring to see the water again rising, brilliant in the sun with gas bubbles, and overflowing the large glass cylinder placed over the spring. In the end the state bought all the springs and established a State Reservation.

Lead Poisoning

The lead question in drinking water came to my attention at an early day. Physicians reported cases of lead poisoning. I will mention a single example. An elderly gentleman's case was diagnosed as lead poisoning. No probable source of the lead could be suggested till the doctor interviewed the cook, and learned that her first duty in the morning was to place the old gentleman's "wheaten grits" cereal in a bowl, draw water upon it and after a while boil it. This fact suggested lead in the water. My attention was called to the subject and I found that water which had stood all night in the pipe of my own house contained a little lead, which might, as lead is a cumulative poison, ultimately produce serious results, if such water were often used. Looking further into the matter, I found that owing to the low pressure in the water pipes a great many houses were provided with pumps, and tanks to supply the upper stories. Examination of the tanks developed the fact that they were usually lined with lead, and the water thus became contaminated.

Examinations were also made of Croton water which had been in contact with lead for different lengths of time, under usually occurring circumstances, of which the following are the results:

1. A gallon of Croton water from a lead-lined cistern, in which it had stood several weeks, was found to contain 0.06 grain of metallic lead.

2. A gallon of water which had remained 6 hr. in the lead pipes of my residence yielded 0.11 grain metallic lead, a considerable portion of which was visible to the eye, in the form of minute white spangles of the hydrated oxycarbonate.

3. Water drawn from one of the hydrants of the School of Mines laboratory, in the middle of the day, when the water was in constant motion, yielded traces of lead. This water reaches the school through 100 to 150 ft. of lead pipe.

These results indicated the source of many hitherto unaccountable cases of lead poisoning, and are of a character to alarm the residents of New York, and lead them to adopt precautionary measures for protection against this insidious cause of disease.

A celebrated case occurred in the royal family of France, at Claremont, where one-third of the persons who drank of the water were affected. This water contained only $\frac{1}{10}$ grain of lead in a gallon. As little as $\frac{1}{100}$ grain of lead to the gallon has been known to

produce palsy in persons who habitually drank it. It is a great pity that the peculiar advantage of lead as a material for the manufacture of water pipes is more than counterbalanced by the danger of lead poisoning. These last paragraphs are quoted from a letter delivered before the American Institute in the Academy of Music, Jan. 20, 1871.

This subject attracted a great deal of attention at that time. The Board of Health put an end to the use of lead-lined tanks and the public was warned against drinking water that had stood long in the pipes. About this time tin-lined lead pipe was invented. It was made by casting lead around a hollow cylinder of tin, and then drawing the mass down to a pipe of the desired size. I found that the heat of the melted lead was liable to soften the tin lining to such a degree as to alloy it with the tin even clear to the inner surface of the tube. A suggestion of mine overcame this difficulty. A separate hollow cylinder of tin was placed in a surrounding cylinder of lead of such size as to leave nearly ¼ in. space between the two. Then melted solder was poured between the two cylinders; they were perfectly united without melting the tin perceptibly, and a perfect tin-lined pipe was produced. I used this pipe throughout my country house at West Hampton, and one of the spring companies at Saratoga employed it for a deep spring, using a very large-sized pipe. A test of the proper condition of the pipe was easily made by cutting off a section about 1 in. long, holding it in forceps and carefully heating it over a bunsen burner. If it was in good shape, the solder would first melt, as could be seen by the eye, and the tin tube could be shaken out in a sound condition. If, on the contrary, the lead had alloyed the tin, the entire lining sloughed off on heating. Special joints were devised and the invention was a complete success. But the cost of plumbing was considerably increased, both for material and labor, and the invention never came into general use.

Poisonous Cosmetics

Before I leave the subject of lead poisoning I must say a word with regard to the poisonous cosmetics which I examined in 1869. Hair tonics, washes and restoratives were much advertised and sold. The following are the results of my examinations of those sold in New York City. Only one was free from lead, that was Hoyt's Hiawatha Hair Restorer, which was an ammoniated solution of nitrate of silver, and harmless. Here are the others:

TABLE SHOWING GRAINS OF LEAD IN ONE FLUID OZ.

Clark's Distilled Restorative for the Hair	0.11
Chevalier's Life for the Hair	1.02
Circassian Hair Rejuvenator	2.71
Ayer's Hair Vigor	2.89
Prof. Wood's Hair Restorative	3.08
O'Brien's Hair Restorer America	3.28
Gray's Celebrated Hair Restorative	3.39
Phalon's Vitalia	4.69
Ring's Vegetable Ambrosia	5.00
Mrs. S. A. Allen's World's Hair Restorer	5.57
L. Knittel's Indian Hair Tonique	6.29
Hall's Vegetable Sicilian Hair Renewer	7.13
Dr. Tebbett's Physiological Hair Regenerator	7.44
Martha Washington Hair Restorative	9.80
Singer's Hair Restorative	16.39

These fluids consist of an aqueous solution of acetate of lead, generally containing a sediment of flowers of sulphur. They are to be well shaken before use and when applied at intervals to the hair are said to "gradually restore the originally youthful beauty and color." Six lotions or washes for the complexion were examined, and one contained corrosive sublimate and sulphate of zinc. Seven enamels for the skin were examined; three contained oxide of zinc, three others contained carbonate of lead and only one of the enamels submitted was free of lead.

The Plumbing System

I should be very glad to have had time to explain the improved system of plumbing which resulted from the experimental set of plumbing arrangements which I erected at the Board of Health building, where with a kitchen sink, butler's pantry sink above it, a wash bowl above that, and a bath tub above that, all with glass traps for ready observation, it was easy to demonstrate the absolutely unsafe condition of the plumbing not only in New York but everywhere else in this country.

The result of this was an improvement resulting in carrying the soil pipe through the roof, of undiminished caliber; the back airing of all traps by means of a separate pipe running through the roof; the running trap between the house and the street sewer; and the inlet for fresh air between the house and this trap. This system was approved by the plumbers and fixed by law, and was placed under the control of the Board of Health. It was generally adopted throughout the country, and there was no more talk about sewer gas as a cause of disease. Microbes took its place. Patent traps were not accepted as substitutes for good old-fashioned "S" traps. By the way, I have just learned from A. E. Hansen, hydraulic and sanitary engineer, who is adviser to the Master Plumbers' Association, that an effort is now being made to force the plumbers to adopt a "patent trap." To adopt this would be a crime.

Brief Mention of Other Activities

There are many other topics to which I would delight to call your attention, such as:

My connection with the first production of oleomargarine, that cheap, wholesome article of food which has been so handicapped by the government.

Introduction of cheap water gas here and in Boston, and sustaining the Lowe process for its manufacture.

My study of sugar refining in Europe in 1869, and the Hunters Point nuisance.

I should also enjoy telling you of the splendid work of Miss Louisa Lee Schuyler in rescuing 2,500 pauper insane from the state poorhouses and placing them in state insane asylums, where they had some chance of recovery. And of Mrs. Kinnicutt's very successful campaign to secure an efficient street cleaning department.

In both of these enterprises I was honored with the responsibilities of president of the associations which the ladies organized, but the credit of these great reforms belongs entirely to them.

I must also call attention to the lion's share of the work in my report on the air of the subway, published when that public utility was first opened and certain individuals erroneously pronounced the air therein so unwholesome. Dr. Floyd J. Metzger performed the laborious portion of the investigation.

I wish I could take the time to tell you how much certain members of this Chemists' Club have contributed to the success of the City and State Health Departments: Elwyn Waller, Samuel A. Goldsmith, Edward G. Love, Arthur H. Elliott, Charles E. Munsell and others whose names I do not just now recall.

In conclusion, let me express my appreciation and warmest thanks to the members of your committee, who have considered me deserving of this medal.

Teaching Chemical Engineering in Columbia University

Outline of the Chemical Engineering Curriculum at Columbia University as Instituted in 1915—Theory and Practice Combined in a Manner Considered to Meet the Demands of Industry

By ELLWOOD HENDRICK

COLUMBIA UNIVERSITY, founded in 1754 as King's College by royal grant of that second scion of the house of Hanover who called himself "Shorsh," is now the most largely attended university on the continent. Indeed we believe that it holds the world's record for attendance, the registration for this year being about 25,000. The fact, however, is of less importance to us than that Columbia addresses itself more particularly to post-graduate studies than most other American institutions of learning. With this in view, and bearing in mind its development as a university, the authorities decided that the engineering professions were of a learned nature, and that the same measure of preparation—but not the same preparation—is necessary for any of its seven engineering courses as is required for law, divinity, or medicine. The question whether, for instance, a chemical engineer should be an astute pipe-fitter or a cultured professional man with all the consciousness of professional obligation and with training in pure science to understand the philosophy of his work as well as its details was answered very clearly by the Columbia authorities. And its present engineering schools which require a minimum of six years from college entrance are founded upon the theory that engineering is a professional institution. This must not be taken to mean that years of drilling in Latin and Greek are called for. These studies remain optional with the student. What the School of Chemical Engineering demands is at least three years' special preparation in pure science in college, to meet its requirements. A Bachelor's degree in arts without this preparation is inadequate. These requirements involve a working familiarity with calculus and modern languages, and a good grounding in general and inorganic chemistry, as well as in qualitative analysis and in physics. They call for sufficient preparation to enter an advanced physical laboratory course. High school physics and chemistry courses are inadequate.

Pre-Engineering Course in the College

The College gives a pre-engineering course of three years which leads to the entrance of any of its engineering schools, but a Bachelor's degree in science is obtainable only after one year of additional study. The pre-engineering studies cover a course in general chemistry and qualitative analysis, drafting, descriptive geometry, English, history, and economics, mathematics and modern languages, philosophy, physical education, physics and mechanics, with surveying as an elective.

In the Chemical Engineering School there follow three sessions per year instead of the ordinary winter and spring sessions. That is, it is held that the students are men, and that two to four weeks constitute enough of a vacation during hot weather, so that they are required to work during the summer as well as in terms. The same measure of work is demanded for a diploma that was heretofore required for a Doctor's degree; and a Chemical Engineer's degree from Columbia at present indicates that its possessor has completed as much study as is required anywhere else for a Ph.D. degree.

Of course it stands to reason that the degree of Ch.E. indicates a different design in training from that of Ph.D. The Chemical Engineer is prepared to be first a plant foreman, then superintendent, and then manager. The Ph.D. course, on the other hand, is one in which the research idea dominates, and in the industrial field it points toward work in the development of new methods and new articles for chemical manufacturing.

The three-year graduate curriculum for the Ch.E. degree is a full one, as has already been intimated, and it includes three courses in physics, three courses in electrical engineering, four courses in mechanical engineering, three courses in civil engineering, two courses in metallurgy, etc., also courses on chemical factory equipment, factory design, factory management, applied colloid chemistry, and treatment of water and sewage. Not the least important are the two summer requirements and the theses. In the first summer the student spends two weeks in factory inspection, and follows this by eight as a workman in some factory. In the second summer the student works in the Chemical Engineering Laboratory for six weeks, using large-scale apparatus.

From the foregoing we do not learn of a number of features that are included under more general headings. Thus the introduction of biological chemistry in the industrial organic and colloid courses is made an important part of these. It is the opinion of many organic chemists that the use of micro-organisms in organic synthesis is capable of remarkable development, and that it will soon play a far more important part in the economics of chemical industry than at present. This and other subjects are presented to the students in such a

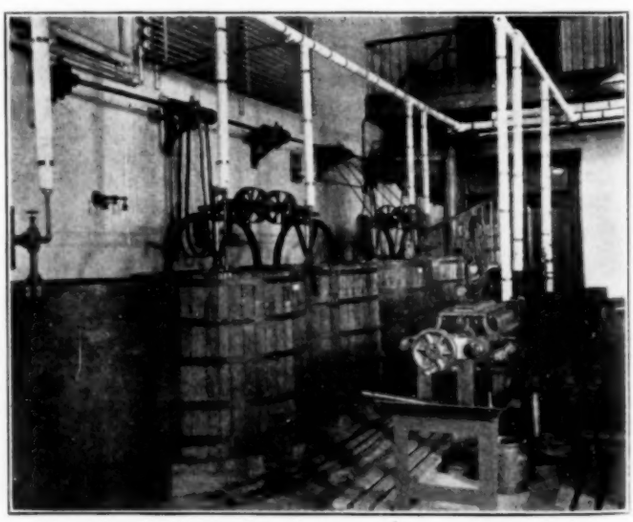


FIG. 1. FILTER PRESSES, PUMPS, SIPHONS, TANKS, AGITATORS, ETC.

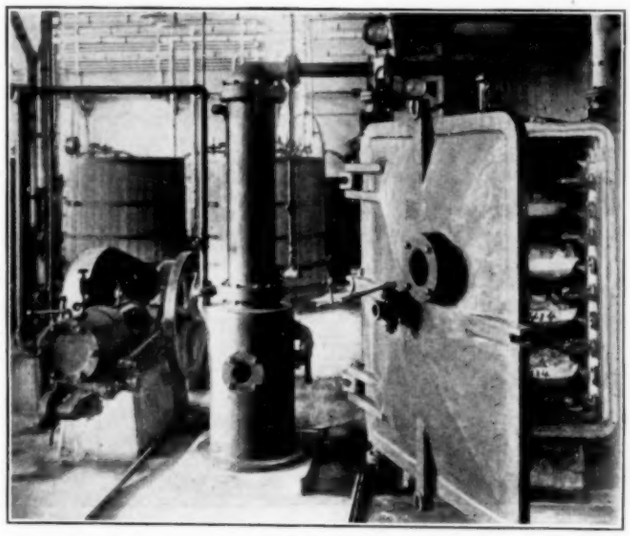


FIG. 2. VACUUM SHELF DRIER, CONDENSER AND PUMP, 42-IN. SHELVES

manner as to enable them to carry on their studies along these lines whenever it may seem profitable to do so. The laboratory has all facilities for biological work. Again, in electrochemistry a great deal of the time devoted to its study is within the organic field. Here also the student gets a medium of research which proves itself constantly in the solution of organic problems.

Enthusiasm of the Students

During the six weeks' summer work in the chemical engineering laboratory at the end of the second year, it is required of each student that he make ten preparations in quantity. This year the students asked for an extra week to complete their work—and they were not availing themselves of labor union hours either. They were working all day and every day. The fact that the course is known to be advanced and severe has caused a group of "selects" to undertake it, and, according to one of the professors, "they fairly eat up work." The Chemical Engineering Laboratory has a great deal of small-factory-scale apparatus. We noted, in passing through, a Kelly, an Oliver, and an Industrial Filtration press, all three gifts this year; of which the same may be said of a Badger drying oven, and a new de Laval separator. We saw a pot still, an autoclave tested to 1,000 lb., a Dopp kettle, a double effect vacuum evaporator, a Pfaudler kettle, and one from Elyria; a Devine drier, a Lummus still, a continuous still, and a Lummus extraction apparatus, a Duriron pump, a small paper beater and drier, a 600-gal. and several 300-gal. tanks and still more. The presence of these apparatuses makes the student familiar with them and their uses, and enables the advanced classes to attack new research problems on an industrial scale under the guidance of the faculty. Through donations of manufacturers who are anxious that students become familiar with the uses of their apparatus the Chemical Engineering Laboratory is becoming almost a Chemical Engineering Exposition!

Carvacrol From Crude Spruce Turpentine

A good example of students' work in the Chemical Engineering Laboratory in which several were engaged was the production of carvacrol from crude spruce turpentine, from a sulphite digester, containing about 85 per cent cymene. This involved roughly ten technical steps as follows: (1) It was steam distilled in a pot still, (2) sulphonated by stirring with 66 deg. Bé. sulphuric acid in a Dopp sulphonator, (3) diluted with water and neutralized with milk of lime, (4) filtered in a Sperry filter press, (5) filtrate treated with soda ash and (6) filtered in a Shriver filter press—to use both types—(7) evaporated to dryness, (8) fused in a Stuart & Peterson fusion kettle with NaOH, the fused mass dissolved in water, (9) acidified with sulphuric acid, and after separation (10) distilled.

Now the recorded yield of the original process was about 60 per cent, but these students, by their care and watchfulness, achieved a yield of over 75 per cent, based on the crude cymene used. Carvacrol is an isomer of thymol, and possesses similar properties. By a new analysis developed during the work it was found that about 8 per cent of their carvacrol *was* thymol. Therefore it is the thesis of another student to develop thymol in the place of carvacrol, from the cymene. That, if it succeeds, will be a noteworthy industrial achievement, for very large quantities of thymol are used.

In the third year, "Chemical Engineering. Thesis" takes up six hours per week during the spring session. A satisfactory thesis is required of each graduate, but the research problems in hand are always of an industrial type, and many of them of a major nature.

In addition to students' theses there are several industrial fellowships, and students may be assigned to assist on these whenever feasible. Of such is one on the utilization of sulphite waste liquors which is extremely promising. It is worth while to remember that in the United States and Canada there are daily thrown into rivers, killing fish, and generally polluting their waters, 4,000 tons of material that should be employed in organic chemical industry.

Some Typical Problems

Some of the typical thesis problems on which young men are laboring this year are:

1. Silica gel and its adsorbing qualities.
2. Commercial production of benzoic acid starting from benzene and not toluene.
3. Prevention of rancidity of artificial butters.
4. Clarification of oils from the colloidal side.
5. Theory of sulphonation: a study of conditions which determine sulphonation.
6. Effort to devise an electrode that will stand between graphite and platinum; an electrode that may be used in an acid oxidizing solution.
7. Production of acetic acid from acetylene without passing through the aldehyde stage.

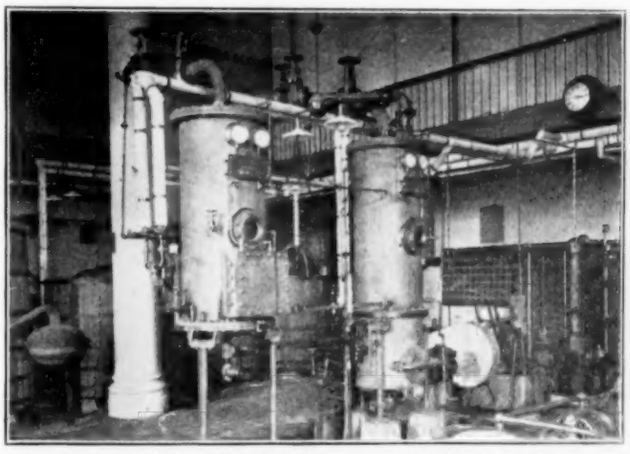


FIG. 3. DOUBLE EFFECT VACUUM PANS (24-IN.) WITH COMPLETE EQUIPMENT—CONDENSER, VACUUM PUMP, CIRCULATING PUMP, SALTING-OUT CHAMBER, ETC.

8. Study of the physical constants of phenol condensation products.

9. Determination of the physical constants of oil shale and its oil on which apparatus may be designed, including heat conductivity, and specific heat of shale, and the specific and latent heat of shale oil.

A typical group of problems given to students of the Engineering course is shown in the following:

(Show Calculations)

1. In the steam distillation which is made from the reducer after the completion of the reduction of nitrobenzene to aniline, how many pounds of 3-lb. steam will be needed to remove in seven hours 900 lb. of crude aniline to the condenser and receiver? (Use 50 per cent over the theoretic amount to care for radiation losses and the slowness with which the last traces distill over.) (Vapor pressure at 98.5 deg. C. is for aniline 45 mm., and for water 715 mm. The latent heat of aniline is 104 calories.)

2. How many gallons of cooling water entering at 70 deg. F. and leaving at 190 deg. F. will be needed for use in the condenser in connection with the above operation?

3. If a copper coil condenser of thin pipe, 1¼ in. diameter were used, how long should the coil be built?

4. Show a heat flow sheet, including calculations, giving the heat changes involved in the reactions where, starting with 800 lb. of benzene, there is obtained successively 1,200 lb. of crude nitrobenzene and 900 lb. of crude aniline?

It will be seen from the above that the course is for thinking students rather than for memorizing ones. Teaching is done as much as possible through the eye. Long lectures are discouraged, and all lectures are made as informal as possible. Machines and pictures of machines are shown, and many lantern slides are used. The Chandler Museum, to which the old Dean of American Chemistry gave so liberally of his time and substance, is a mine of wealth to the faculty.

The school as now constituted has been in operation since 1915. The first class of 6-yr. men graduated in 1918, and there were but three of them. In 1919 there were seven. The class of 1920 has twenty; 1921, twenty-one, and 1922 has twenty-four. It is now up to the same numerical basis as when it was a 4-yr. course. It would be inconvenient with the present facilities to care for larger classes than 30 for each of the six years. The present students come from all over the world: South Africa, China, Japan, East India, France, Spain, England, Chile, and all parts of the United States. All admit that the course is not too long, and some students are returning for an extra year and the Ph.D. degree.

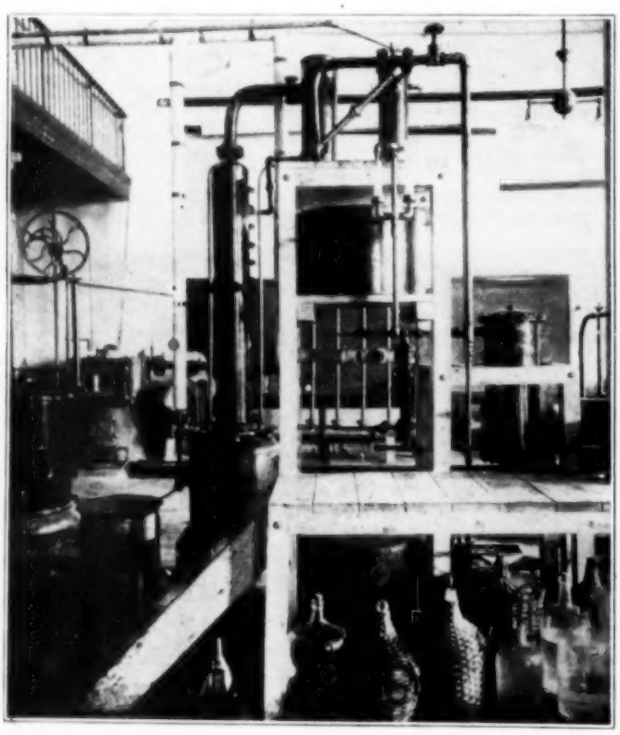


FIG. 4. COLUMN STILL AND EXTRACTION APPARATUS—CAPACITY, 10 GAL. PER HR.

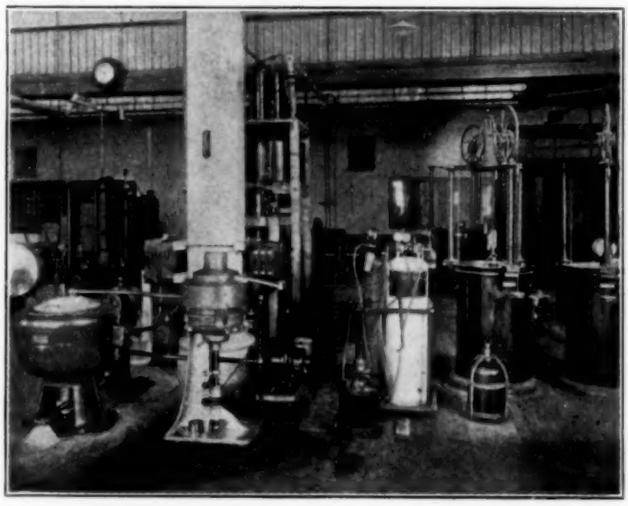


FIG. 5. GENERAL VIEW SHOWING WHIZZER CLARIFIER AND FILTER, WELDING OUTFIT AND GAS HOLDERS

The Faculty of Applied Science of Columbia is headed by the dean, Prof. George B. Pegram, who is also head of the Department of Physics of the college. In the School of Chemical Engineering Dr. Leo H. Baekeland is honorary professor, and gives occasional lectures. He is also a power in council. The executive officer of the department is Prof. D. D. Jackson, and with him is Dr. Ralph H. McKee, also a full professor. In this department are also Dr. A. W. Hixson, Associate Professor and Dr. J. J. Morgan, and Associate Assistant Professor H. B. Faber, with a number of lecturers and assistants having to do specifically with chemical engineering. For all other subjects the school draws upon the great faculty of the university.

New Elmore Process for Zinc-Lead Ores

The new Elmore process for the extraction and separation of lead sulphide from mixed ores, which has been tried out in connection with the ores from the Burma Mines, Ltd., and other ores, is in its main features substantially as follows, according to a note in the *Bulletin* of the Canadian Mining Institute:

"When a mixture of lead and zinc sulphides is treated with concentrated sulphuric acid at 100 deg. C., under proper conditions as regards fineness, proportion, time of contact, etc., the lead sulphide is converted into sulphate, while the zinc sulphide remains practically unaffected If the product is then washed in hot strong brine, the lead sulphate is dissolved, and can then be separated from the undissolved zinc sulphide by filtration, etc. By cooling the hot brine, the lead sulphate is precipitated—except for the amount that cold brine will keep in solution—and the brine can then be reheated and used again. The details, of course, vary for different ores and there are alternative methods for handling the sulphur dioxide, sulphuretted hydrogen or free sulphur liberated during the treatment."

Problems in Electric-Furnace Smelting*

A Description of Investigations to Determine the Best Arrangement of Electrodes, Leads, Etc., of the Ultimate Relation Between Electrical and Metallurgical Phenomena Within the Furnace and of How to Operate a Furnace to Obtain the Highest Output

BY F. HOLMGREN

INTRODUCTION BY TRANSLATOR

IT IS well known that the earliest blast furnaces were built in Sweden, and so also Sweden first successfully solved the problem of the use of electric furnaces for the production of pig iron directly from the ore. The reason for this is naturally to be found in the facts that Sweden has an abundant supply of very high-grade iron ore and cheap water power, which are essential for the commercial success of the process. Coal is very expensive in Sweden and with a small exception the entire consumption has to be imported. It is for that reason that it has been more profitable in the past to export millions of tons of ore annually; but it is hoped that with the successful solution of the electric furnace and its more general adoption, a large part of this ore may be reduced at home and used in expanding the steel mill industry of the country.

Besides iron ore and limestone, charcoal has in the past been the other necessary raw material, but it is stated that recent improvements in the construction of these furnaces make them equally suitable for the use of coke in place of charcoal. The scarcity of charcoal in the United States is undoubtedly one of the reasons why this type of furnace has not been more extensively tried out in this country, and if it is true that coke is a satisfactory reducing agent, we shall undoubtedly soon find many of these furnaces installed here.

There are at present thirteen of these furnaces in operation in Sweden, and four under construction of capacities up to 6,000 kw. each. There are also seven under construction in other countries, several of which are said to be for using coke as a reducing agent. The productive capacity varies from three to four tons of pig iron per kw.-yr., depending on the quality of the iron produced.

The following article is of considerable interest in that it deals with a number of investigations which were made on existing furnaces in order to determine the best arrangement of electrodes, leads, etc. In one case, for instance, the power consumption was reduced from 474 kw. to 282.5 kw., or 40 per cent, simply by changing the connections from transformer leads to electrodes; moreover, the power factor was raised from 0.7 to 0.91. It also explains the intimate relation between the electrical and metallurgical phenomena within the furnace, and how the operation of the furnace can be controlled for the highest output by a close observation of the electrical measuring instruments.

INVESTIGATIONS OF FURNACE OPERATION

The Helfenstein Furnace.—The investigations were begun with furnace 3 at Domnarfvet Steel Works. This furnace was built by Helfenstein and showed the poorest results, both as far as operation and power consumption per ton pig iron were concerned. The heat had a tendency to rise higher and higher in the stack and the heat losses were considerable. The electrode potential could not be brought up to the desired value, and it was thought that this was due to too short a path of the current. To overcome this, water-cooled bridges were provided between the electrodes in the furnace dome in order to force the current to pass through the bath. The energy losses in the leads between the transformers and the electrodes were measured by the three-voltmeter method and found to be not less than 17.5 per cent of the total capacity.

The above changes and numerous other tests and trials failed to improve the results, and similar investigations were started at the Soderfors Steel Works.

The Soderfors Furnace.—This furnace, which is of the "electrometal" type, had shown much better operating results than the Helfenstein furnace at Domnarfvet, but on the other hand the power factor was lower than for furnace 2 at Domnarfvet, which also was of the electrometal type. Electrically, the principal difference in the arrangement was that with the former the transformers were installed in a separate room about six meters from the center of the furnace, while for the latter they were placed immediately near the furnace wall. The frequency in the former case was 50 and in the latter 60.

In these tests complete voltage diagrams were drawn by means of the three-voltmeter method, whereby the losses and the inductive voltage drop in the different leads could be determined. All the measuring instruments had before always been connected to the transformer terminals or near these, whereby the effect of the leads from the transformers to the electrodes was included. This, of course, was not the correct method, as what is most valuable for a study of the furnace operation is a knowledge of the current and voltage at the electrodes proper.

In the first test of the Soderfors furnace a relatively symmetrical voltage diagram, Fig. 1, was obtained, and the losses amounted to 474 kw., or to about 16 per cent of the total capacity. In the diagram the losses F are shown as the projection of the voltage drop on the current I. Points T represent the transformer terminals and E the electrodes. The diagram shows, however, that the furnace was not symmetrically connected, so that the six electrodes will not follow one another in the same sequence in the voltage diagram as in reality.

With currents up to 20,000 amp. or more, which are common with these furnaces, the magnetic fields set up about the conductors become very strong if not compensated for. In this installation, which is three-phase at 50 cycles, the direction of current will change 100 times for each second and the three currents will be

*Abstracted and translated from the *Transactions* of the Swedish Iron Institute by E. A. Lof.

displaced with respect to each other one-third period. If now the same current is carried forth and back through two adjacent conductors (one going and one return conductor), then the electromagnetic fields set up by the two conductors will be equal but opposite. The conductors will therefore compensate each other, and there will, practically speaking, be no electromagnetic field. If, however, a conductor is placed adjacent to

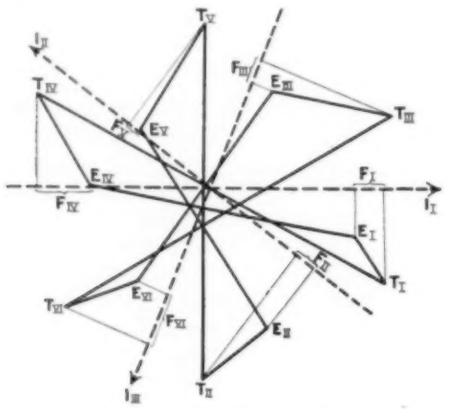


FIG. 1. CURRENT AND VOLTAGE RELATIONS IN SODERFORS FURNACE

another, and one carries a different current, or current of a different phase than the other, then the electromagnetic field will be greater or less, depending on how the fields set up by the two currents will combine vectorially.

In the diagram, Fig. 2, are shown the results from the first test of the Soderfors furnace. The strength and phase-displacements of the currents are drawn to scale, and represent also the electromagnetic fields set up. Besides this, there is shown in the smaller diagram the leads around the furnace and the direction of the currents therein. The directions of the arrows thus correspond to one another in the two diagrams. We see therefore in the smaller diagram how the arrows of the conductors between electrodes *I* and *II* have the same direction, while between the other electrodes this is not the case. The resultant of the two currents, therefore, gives a field proportional to $R_{I,II}$. The two others will, on the other hand, be respectively $R_{II,III}$ and $R_{III,IV}$. The electromagnetic fields which thus surround the conductors will be increased by adjacent iron structures which will lower the magnetic reluctance. Such structures are the furnace casing, iron pillars, etc. In these iron parts eddy currents are now in turn set up, which are converted into heat. The less compensated the leads, the greater will be the iron losses thus created. The fields will besides set up electromotive forces in the conductors themselves, which may cause a drop and even a rise in the voltage.

Losses Reduced by Interchange Electrode Leads

The terminals of the transformers for electrodes *III* and *IV* were then changed so that the direction of the current in the circuit was reversed. The result was measured and is shown in Fig. 3. At a first glance it would seem as if the first connection would have been the correct one on account of the symmetrical and otherwise clear vector relations. The unsymmetrical diagram depends, however, on inherent conditions in the furnace which will be dealt with later.

From the diagram it follows that certain losses ($F_{I,II}$, ...) have become negative, that is, that a power increase has taken place instead of a loss. This is readily explained. On account of the above-mentioned mutual induction a certain amount of power has been transformed from one lead to the other, in that the former has acted as the primary winding in a transformer and the latter conductor as the secondary. The adjacent iron structure has served as the necessary "transformer" core. If we consider the fields which could have been formed around the conductors, we find (Fig. 4) that in the latter case these have become much smaller, which must result in lower additional losses. This proved to be the case, as the losses went down to about 375 kw.

The low power factor caused by the relatively large inductive voltage drops (represented in Fig. 1 by the lines at right angles to the currents) could not, as expected, be improved by this reconnection, and it was then suggested that the transformers should be connected to adjacent electrodes instead of to opposite ones as had been done before. Investigations involving the inherent electrical conditions of the furnace were made and it was found that this suggestion was practicable.

If we assume that an electrode of circular cross-section with radius r cm. is lowered to a depth of h cm. in a conducting homogeneous mass with a specific conductivity c, then the resistance which the current has

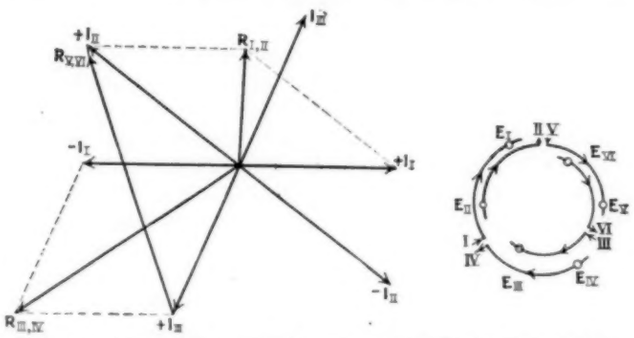


FIG. 2. MAGNETIC FIELDS AND ELECTRODE CONNECTIONS FOR FIRST TEST

to overcome in its travel from the electrode to a concentric cylinder area with the radius R cm.:

$$M = r\int \frac{Rdx}{x} \cdot \frac{c}{2\pi h} = \frac{c}{2\pi h} \log_e \frac{R}{r} \text{ ohms.}$$

From this we get the voltage

$$E = \frac{Ic}{2\pi h} \log_e \frac{R}{r}.$$

The energy production per unit volume will therefore be

$$\frac{dU}{dx} = \frac{1}{x^2} \cdot I^2 \frac{c}{2\pi h} - \text{const.} \frac{I^2}{x^2}$$

and will therefore drop rapidly the farther the distance from the electrode.

The zone nearest the electrodes may be considered as consisting of a number of parallel arcs, where the resistance and the voltage drop presumably follow other laws. Oscillograph tests of the applied current and voltage have shown that these have a practically sinusoidal wave shape. Whether this was due to impossibility of connecting the oscillograph sufficiently near the arc itself, to the heat capacity of the arcs, or to other causes, could not be determined. This resistance may depend, however, upon the current density, the

temperature, the composition of the charge, and the distance between the electrode and the bath. Besides this, the gas currents and finally the electromagnetic field may have their influence.

Distinction Between Working Resistance and Conductor Resistance

It is in this zone presumably the principal direct energy generation takes place. Outside of the zone the above laws may hold, excepting that the resistance will increase with a falling temperature. The energy generation drops therefore less rapidly than the formula would indicate. In the former zone we thus have the real "working resistance" and in the latter the "conductor resistance" to the next working zone.

There is no doubt that the "working resistance" preponderates, but it is not quite clear what rôle the "conductor resistance" to the next working zone plays.

This electrical condition with two such zones is known by the term "free" electrodes, and represents a normal operating condition. If no arc zone exists, we say that the electrodes are "frozen." This occurs when the potential required for maintaining the arc cannot for

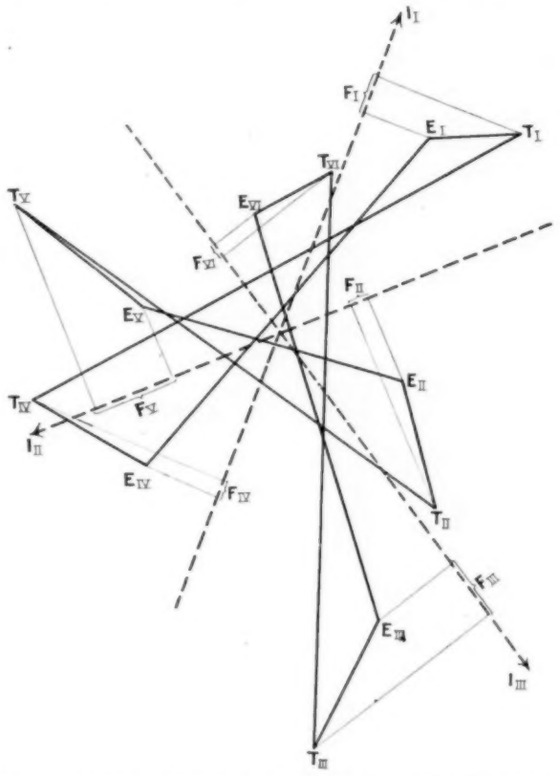


FIG. 3. DIAGRAM WITH LEADS TO III AND IV (FIG. 2) REVERSED

some reason or other be produced. The condition appears as a lowered "working resistance" (consequently increasing current), rising temperature in this part of the hearth and reduced production.

Regarding the effect which the "conductor resistance" in the mass itself may have and its effect on the heat development in the furnace, it may be of interest to determine how the different currents proceed through the crucible.

Fig. 5 represents the progress of the currents within the furnace when complete symmetry exists, that is, when the currents in the three phases are equal, the furnace connections symmetrical and non-inductive and when the currents enter and leave the crucible through opposite electrodes. We find that the currents entering will divide according to the parallelogram law into components such that the current between either of the electrodes will be equal to the current entering.

In connection with the first investigations of the

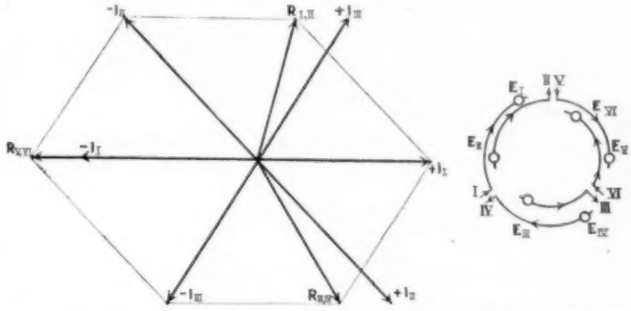


FIG. 4. REDUCED MAGNETIC FIELDS WITH LEADS TO III AND IV REVERSED

Soderfors furnace it was found after the shut-down that the lining was more corroded between certain electrodes than others and it may be assumed that the greatest effect in the mass took place there. It is, however, difficult to say whether this really had anything to do with the two conditions referred to or was just a circumstance.

It has not been possible to determine the effects of the unsymmetrical condition and the different currents passing through the charge, but from the voltage diagrams it is fairly evident that even the "conductor resistance" of the mass is a factor which must not be lost sight of in considering the heat distribution in the furnace. The diagrams thus show that there is far from a common neutral point, for which reason it must be assumed that work has also been done by the currents in the mass. Cold spots between certain electrodes were thus found in the Soderfors furnace. There is some uncertainty as to the magnitude of the work done in the mass itself between the electrodes and its effect on the thermal procedure within the furnace.

Best Results by Connecting Transformer Leads to Adjacent Electrodes

Regardless of how the effects are distributed on the arc zones and in the mass itself, we see therefore that the current paths will not be any longer if the transformer terminals are connected to two opposite electrodes than if they are connected to two adjacent electrodes. It was therefore decided to change the connections so that each phase was connected to two adjacent electrodes. The result was, as expected, a considerable reduction of the losses in the conductors, which went down from 375 to 282.5 kw. with the same operating condition of the furnace. The power factor, furthermore, was improved to such an extent that from a power consumption of 4,420 kva. now only 3,395 were required, or a saving of not less than 23 per cent in kva., resulting only from the rearrangement of the leads. The power factor improved from 0.7 to an average of 0.91.

Electrometal Furnace 4 at Domnarfvet.—This furnace showed, to begin with, the same trouble as the Soderfors furnace before the leads were rearranged. Furnace 4 has eight electrodes arranged with a double "Scott" connection, and is therefore equivalent to a doubling of the set at Trollhattan.

The power factor was found to be low, hangings occurred and the operation was for this reason uneven at the different electrodes. The leads were arranged as for the Soderfors furnace, that is, the terminals of the respective transformers were connected to diametrically opposite electrodes. Very thorough investigations were made on the furnace.

In Fig. 6 is shown a complete vector diagram of the connections in which the magnitude and direction of the currents and voltages are marked. As there is no real neutral within the furnace, that shown in the diagram will be regarded as fictitious. The great difference, both in magnitude and direction, between the voltages at the transformer terminals and at the electrodes, is at once apparent. For electrode 6, for example, the voltage between the corresponding transformer terminal and neutral is about 41 v., while between the electrode itself and the neutral it was found to be only about 15 v. The phase-displacement with reference to the fictitious neutral was in the former case only about 0.16 and in the latter about 0.8. It is therefore apparent what little help we have from instruments connected to the transformer terminals, as a guide for operating the furnace.

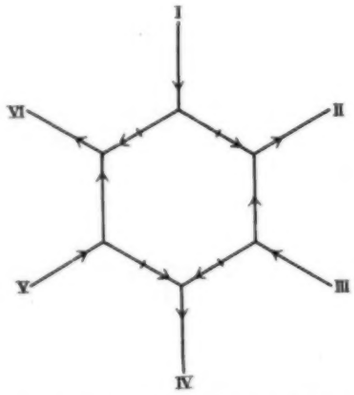


FIG. 5. CURRENTS IN THE FURNACE FOR BALANCED CONDITION

Analysis of Losses

From this diagram it was now possible to approximately determine the distribution of the losses in the different parts of the conductors, and the values so obtained have been combined in Fig. 7. This shows still more clearly the faulty interpretation one may get from the instruments as regards the load on the different electrodes. So, for example, the wattmeter indicated a load of 1,020 kw. for electrodes 4 and 8, while in reality the electrodes received only 637 kw. Still more peculiar is the result at electrodes 2-6, where the meter indicated 744 kw., while in reality the electrodes received not less than 1,019 kw. This big difference can be explained by an insufficient interlacing of the conductors and the fields thus set up, besides the transformation of work from one conductor to the other.

At the test in question a total of 3,942 kw. was applied, of which only 3,392 kw. were useful in the furnace, leaving a 603-kw. loss in the 80 m. leads between the transformers and the furnace. These were segregated as follows:

Losses in the contact terminals:	kw.
At the electrodes	122.2
In the leads themselves	164.2
In surrounding iron structures	316.6
Total	603.0

From one set of conductors to another there was transformed no less than 544.4 kw. With a rearrangement of the leads to correspond to that at Soderfors, it was estimated that the losses could be cut in two. Regarding the furnace leads, the following rules can therefore be laid down:

The low tension conductors should be so arranged that adjacent electrodes are connected to two opposite transformer terminals, and that these + and — circuits are carried the shortest distance and in such an interleaved manner that the magnetic fields will be neutralized.

The measurements give a clear picture of the electrical properties up to the electrodes and teach us the best method in which to arrange the leads. Inside the furnace we know that the resistance can be divided in a "working resistance" in which the principal energy is developed, and a "conductor resistance" between the electrodes. It has been shown how the currents pass through this conductor resistance, but it has not as yet been possible to determine the relative magnitude of the two resistances, which undoubtedly has an intimate relation to the operation and the furnace temperature.

It can safely be assumed that unequal heat supply also was the cause of the irregular operation which was noticed both in furnace 4 at Domnarfvet as well as in the Soderfors furnace before the connections were changed, while the performance of furnace 2 at Domnerfvet was decidedly better from the beginning. As seen from Fig. 8, the leads did not here cause the same disturbing effect on the instrument readings. Regardless of how the furnace leads are arranged, the instruments must always be connected as close to the electrodes as the heat radiation from the furnace will permit. With a perfect arrangement of the leads, then, this is of course not so important, as confirmed by Fig. 9, which represents a voltage diagram of the Soderfors furnace after the leads had been changed. This diagram should therefore be compared with diagrams Figs. 1 and 3, but above all with Fig. 6.

From the preceding there is good reason to believe that there exists a certain reciprocal action between the electrical and metallurgical phenomena of utmost importance inside the furnace.

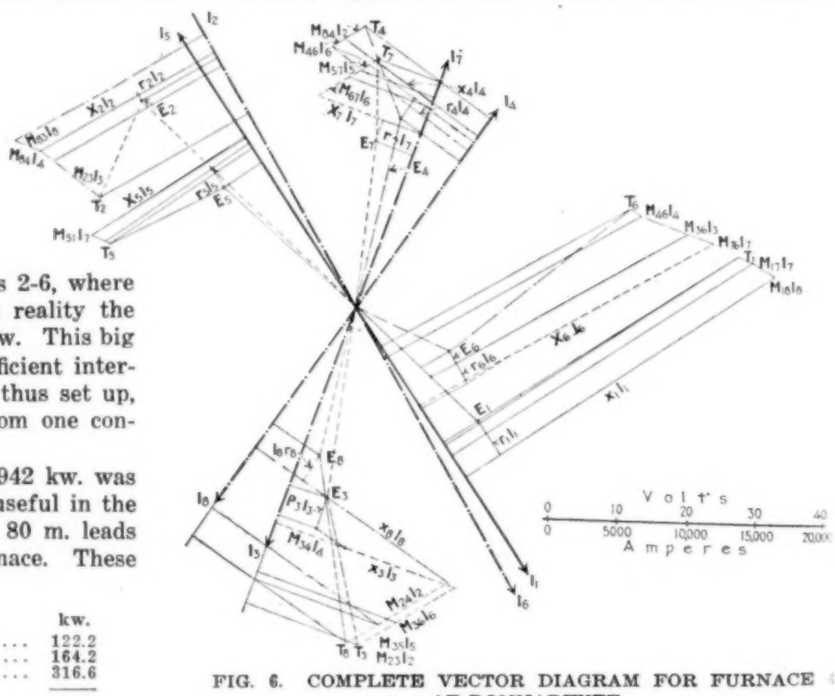


FIG. 6. COMPLETE VECTOR DIAGRAM FOR FURNACE AT DOMNARFVET

Earlier investigators have already dealt with the equilibrium of electric-furnace operation in that with a surplus of coal the operation will readily become "hot," meaning that the furnace temperature would be above normal, while with a surplus of ore it will become "cold," meaning that the furnace temperature would be below normal. The former condition is characterized by a tendency of the current to rise, that is, the resistance in the furnace drops and the temperature rises with reduced operation. Referring back to the previously mentioned division of the resistance inside the furnace, we find in the first place that the "working resistance" drops, which undoubtedly depends on the reduced operation.

It may be possible that this takes place in the following manner in that in the active arc zone the reduced iron drops down into the bath below the electrodes, and the carbon monoxide escapes the easiest way along the electrodes up to the stack, whereby the section nearest these will be exposed to an unusually severe heat.

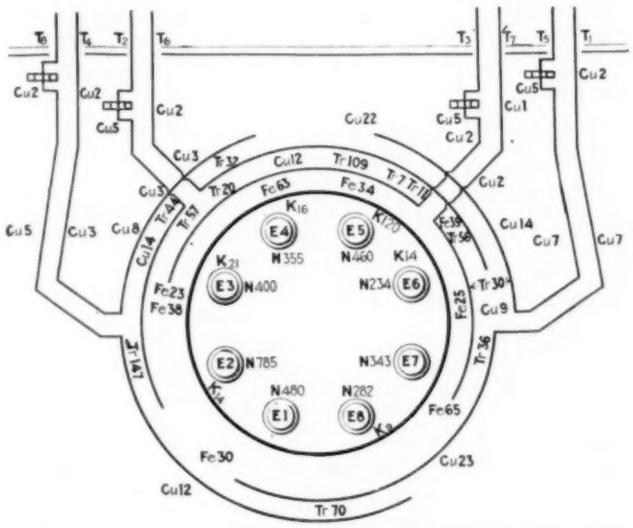


FIG. 7. LOAD DISTRIBUTION TEST OF DOMNARFVET FURNACE 4

The gas blast will cool the mass and the arch between the electrodes, whereby at least the upper part of the mass between the electrodes will have a relatively low temperature and a correspondingly higher resistance.

If now there is a reduction in the operation on account of a surplus of carbon, then the real smelting zone, which therefore practically contains iron drops and rising carbon monoxide, will be thinner and thinner, and the working resistance will drop. The surrounding zone, which practically consists of conducting carbon, will be forced more and more toward the electrode, until it finally sticks to the same, and the "working resistance" ceases more or less to exist. The resistance between the electrode and the mass is thus exceedingly small and the current rises considerably. As the reaction $FeO + C = Fe + CO$ is strongly endothermic, and as any cold charge is prevented from descending into the bath, the reduced operation will always mean an increased heat supply to the mass surrounding the electrode, which also in turn lowers the resistance in the mass between the electrodes. If in the charge, when it enters the hearth, there is a certain surplus of carbon in proportion to the available oxygen for formation of CO, then there is, of course, no possibility for this to oxidize, as, contrary to ordinary blast furnaces, the mass is not passed through by any gas with an oxygen surplus. An accumulation of carbon will then take place which will more and more prevent the charge from descending and a reduced operation will result. Such carbon accumulations are especially apt to take place when coke is used on account of its compact nature and its tendency to graphitize.

The "cold" operation, on the other hand, is characterized by the fact that with a rich easy reducible ore there will be a too large arc zone around the electrode with accompanying high "working resistance." On account of the increased operating condition, the surrounding mass will not be sufficiently supplied with heat, but will solidify. The arcs between the electrode and the mass will finally go out and the operation will stop.

Unbalanced Operation Between Electrodes

As has been pointed out above, the heat supply has often proved to be very irregular at the different electrodes. On the other hand, it seems to be true that the arc zone, which is desirable for a successful and regular operation of the furnace, has a certain relation to the operating conditions of the electrode in question. As soon as the charge around the electrode reaches an unsuitable composition (surplus of coal or ore) it has been found that the operating condition becomes bad, either due to electrical heat supply with accompanying disturbance of the electrical phenomena (during "hot" operation) or because the electrical phenomena have been disturbed with an accompanying checking of the electrical heat supply (during "cold" operation). In the former case an increased ore supply is resorted to and in the latter a reduced supply.

That the heat in electric furnaces is very unevenly distributed cannot be disputed, and that an uneven energy supply through the electrodes will still further increase this condition is self-evident. The result of this has also often shown itself during tappings, in that the iron then often shows a changing temperature.

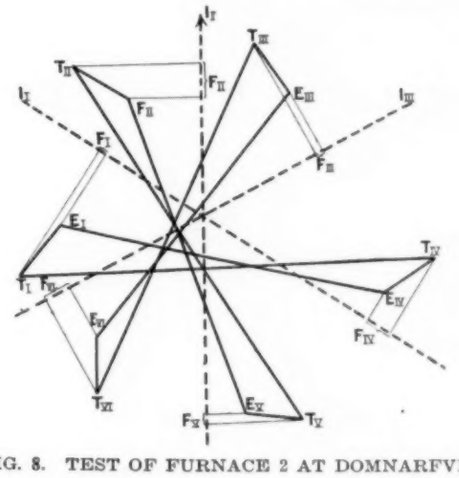


FIG. 8. TEST OF FURNACE 2 AT DOMNARFVET

It even sometimes happens that at tappings iron and slag will be poured in alternating successions.

It shows therefore that there has been an irregular metallurgical condition at the different electrodes, depending partly on the uneven energy supply and partly on a different composition of the charge at the different electrodes. At one electrode the furnace may thus show typically "hot" operation with a low effect, while the operation at the other electrode may be entirely

normal. The uneven successive tapping of iron and slag can naturally also be due to the fact that under each electrode there has been formed an individual iron bath with accompanying slag cover, which confirms the unequal heat distribution within the furnace.

Electrodes Should Be Controlled Individually

It seems therefore that the crucible of an electric furnace can be considered as consisting of a number of furnaces equal to the number of electrodes. When the operation of an electrode tends to get "hot" it should therefore be possible to prevent this by cutting off the current from this electrode for such a length of time that the surplus of carbon may be removed in some manner. As an increased ore supply through the stack affects all the electrodes, it would seem that in order to obtain a steady operation of the furnace the electrodes should be controlled individually. With "hot" operation, ore should therefore be supplied through special holes in the dome to the respective electrodes if such holes will not unduly weaken the furnace construction.

The uneven distribution of coal and ore in the charge, which is liable to cause a "hot" operation, should therefore be avoided by a careful mixing before the charging. If ore and coal are supplied to the furnace in the ordinary way in form of alternate layers, it is possible that the profile of the stack may influence the charge at the electrodes. If we follow the layers down through the stack, we find that the sinking will be more rapid in the center of the stack on account of the friction against the walls, Fig. 10. It is therefore possible that the occasional surplus of coal is due to the fact that a layer of coal, or a part thereof, during its progress through the bosh, will take up a position parallel to the

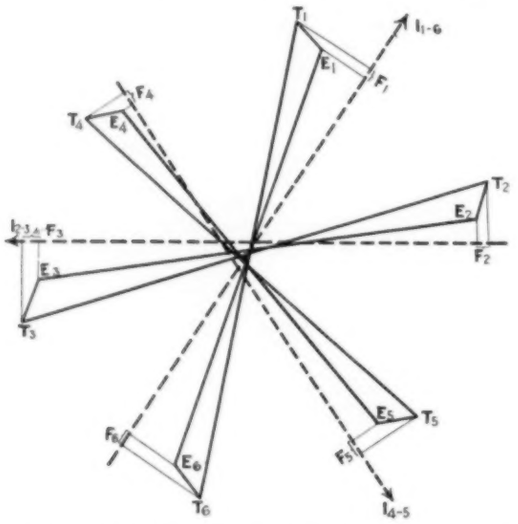


FIG. 9. VOLTAGE DIAGRAM FOR FURNACE WITH CORRECT ARRANGEMENT OF LEADS

electrodes, and finally surround the same in the form of a mantle and thus prevent the operation with a resulting over-heating.

Another kind of "hot" run is also possible, namely, when the electrode is unable to burn itself free and form an arc, regardless of the fact that the charge does not contain any local or general surplus of carbon. This may depend on the special nature of the electric-furnace process, in that the furnace can be supplied with only a sufficient quantity of electrical energy required by the process on the supposition that this is produced in arcs. By simply conducting the circuit through the charge it is not possible to produce the required energy and heat for the furnace, on account of the limited low value of the resistances. Why a reaction corresponding to this energy does not take place in the mass so heated and thus cause reduced operation, is difficult to explain. Instead we obtain a surplus of heat in the furnace. It may possibly be caused by the fact that the smelting process ceases and that therefore the reduced material is not removed as rapidly as necessary.

Causes of Operation With "Frozen" Electrodes

This corresponds to what was found with the Helfenstein furnace. A low electrode voltage could not be used on account of the inside resistance of the furnace. The operating capacity was very small and the operation very "hot," the heat rising further and further in the bosh and stack. As soon as a higher voltage could occasionally be noticed at any of the electrodes an increased capacity was also observed. The electrode has then very likely burnt itself free, while the Helfenstein furnace thus "normally" ran with frozen electrodes. The reason for this might have been that the contact surface between the electrode and the mass, due to the furnace construction, was too great, so that the energy required for burning the electrode free was greater than could be produced with the arrangements of the leads, etc.

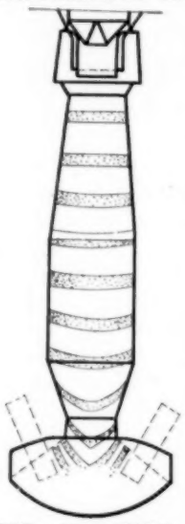


FIG. 10. PROGRESS OF CHARGE THROUGH THE FURNACE

"Hot" operation due to the same cause was also noticed in the Soderfors furnace before its reconstruction. The great distance to the bottom of the furnace made it often necessary, especially with hangings, to push the electrode far down in order to get any current to pass. When then the charge fell, the reaction surface became too great and the electrode was unable to burn itself free. On account of the great free length of the electrodes within the crucible and their slope with respect to the "falling-down" angle of the mass, they were often broken. The remaining stump was then quickly pushed down to prevent burning of the roof, and contact with the broken-off part was established, with the result that the reaction surface became still greater and a burning-free was impossible. Since the height of the crucible has been considerably reduced, any "hot" runs from this cause have not been observed.

Reducing Losses by Rebuilding the Crucible

As a result of the rebuilding of the crucible, it may be noted that with a suitable electrode surface in the mass, the current became relatively low, which, of course, was of greatest importance as far as the secondary transformer windings and the low-tension leads were concerned. It was furthermore possible to keep the voltage high without unduly overheating and damage to the furnace lining. The low current had an especially favorable effect on the losses in the conductors, as these were reduced to only about 180 kw. from 282.5. The inside resistance of the furnace was increased from 1,250 microhns per electrode to not less than 2,700 michrons, and it is, of course, desirable to keep this

resistance as high as possible. The upper limitation is the risk of "cold" operation with a rich charge and irregular operation on the whole due to the tendency of the arcs to go out, besides the silica reduction.

From the above it is apparent that it is very important to use electrical measuring instruments for obtaining a knowledge of the metallurgical progress inside the furnace. The operation is closely related to the load for the same charge, and it is necessary to gain a knowledge of the resistance which is obtained in the furnace for different compositions of the charge, in order to determine on the best operating method therefor. With a charge rich in ore and thus low resistance, for example, it is not permissible to wait with the lowering of the electrode until the same voltage is reached as with a poorer charge with a relatively high resistance.

Points of Consideration in Planning New Electric Furnaces

Frequency. Some of the furnaces with the original arrangement of the connections, that is, with the transformers connected to opposite electrodes, operate with 25 cycle power and a good power factor. There are also several furnaces with the new arrangement of connecting the transformer to adjacent electrodes in operation on 50 cycle power, with good power factor results and low losses in the conductors. If the leads, therefore, are correctly arranged it may be stated that electrical furnaces can be satisfactorily operated with any of the standard frequencies now in use.

Electrodes. There are two ways in which the capacity and thus the production of a furnace may be increased. One is by increasing the electrode diameter with the number of electrodes remaining the same, and the other by increasing the number of electrodes, keeping the diameter the same. Both these arrangements necessitate an increase of the current supply. An increase of the voltage is, however, not permissible on account of the irregular operations which would result therefrom and the effect which the voltage has on the furnace process in reducing the silica. Of the two first named arrangements, an increase in the size of the electrode will surely result in an increased operation on account of the larger smelting zone which is thus obtained, but the difficulties with the current supply will also grow in that the "useful" area of the electrodes, due to the skin-effect, will not increase in the same proportion to the actual area. Besides this there will be increased difficulties in connection with the leads for carrying the large currents. It seems, therefore, as if more can be gained by the second alternative, that is, by increasing the number of the electrodes. At present there are furnaces with 4, 6 and 8 electrodes, and from the electrical point of view there is no reason why the number cannot be increased to 9. The "neutral" column of the charge is, however, likely to be larger and larger, and it may be questioned whether it would not be advisable from an operating standpoint to raise the bottom of the crucible in the center when the diameter has reached a certain dimension, provided that this would not cause an increased pressure of the charge against the electrodes.

Electrode Terminals. This is generally one of the weak points in electric-furnace installations, and every effort should be made to improve the same. A good contact is essential, as about 30 to 40 per cent of the losses from the transformers to the electrodes are to be found here. Arrangements should also be made to facilitate a quick change of electrodes and an easy raising or lowering.

Leads. As has already been explained, the tests and investigations have shown conclusively that the leads must be arranged in a manner which will reduce the resultant electromagnetic fields to a minimum. Conductors which carry the same current but in opposite direction should be placed together as close as possible. This led to the suggestion of connecting adjacent electrodes to the same transformer phase, whereby a much better power factor is obtained and also shorter connections and lower losses therein. The form of the conductors is also of great importance with alternating currents when large currents have to be handled, on account of the influence which the electromagnetic field around the conductor has on the current distribution within the conductor, reducing the useful area. It has also been proved that with uncompensated conductors very little is gained regarding the current distribution therein whether these consist of multiple or solid bars. Better radiation is, of course, obtained and therefore a lower direct current resistance, but the current within the conductors will nevertheless be distributed as if the conductor had been solid. Where the conductor run is uncompensated, that is, where it is impossible to interleave + and — bars, it is advisable to arrange the conductor in the form of a pipe, two half pipes or eventually as four bars arranged to form a square. At 50 cycles it will be possible in this manner to bring down the losses to less than one-half of that with parallel bars. In other words, only one-half the amount of copper need be used in these portions of the leads.

As far as the compensated part of the leads is concerned, much has been done to reduce the surrounding electromagnetic fields by interleaving the + and — bars. For the same area the resistance will also be lower if the thickness of the two outside bars is made only one-half of the inside ones. Where the individual bars are of different lengths the longest ones should be placed outside so as to obtain as low field as possible around the same. Each bar should preferably be connected to an individual transformer winding, and in such case the forward and the return conductors should be bunched and interleaved. They should also be arranged so that the voltage drop in the conductors to the individual transformer windings will be as nearly alike as possible, in order to assure an equal distribution of the load among the different windings. When pipes are used for the leads the amount of copper can be reduced by water cooling. The losses will, however, be higher. Such water-cooled pipe conductors are often used in the leads nearest the electrodes where the heat from the furnace is excessive.

Electrical Arrangement. From what has been said in the above it is evident that the shorter the leads the better will the operation be from the electrical point of view. This was fully demonstrated in furnace 2 at Domnarfvet, where the transformers were placed immediately adjacent to the furnace, and where the operation was the best from the beginning. From the general operating standpoint, however, this arrangement has many disadvantages, in that it takes away much of the space nearest the furnace which is essential for the operation otherwise, and besides this the transformers are directly exposed to the heat from the furnace. This

arrangement has therefore not been followed in the later installations, where the transformers have been placed in a common room separated from the rest of the installation. This transformer room has in different installations been located at different elevations with respect to the control platform, but the leads have generally been carried along the ceiling above this platform and from there down to the electrodes. It would seem advisable, however, to install the transformers at such a height that their terminals would be at the same elevation as the electrode terminals; in other words, the leads should, if possible, be installed in a single horizontal plane.

Furnace Operation From the Electrical Point of View

In the preceding it has often been pointed out that in the electric-furnace process the metallurgical and electrical phenomena have an intimate relation to one another, and from this it follows that the operation must be with this in view.

The problem is to produce the greatest quantity which the limitations of the installation will permit, and this with due consideration of the quality of the product. When such a furnace can produce up to 10,000 tons of pig iron per year and possibly more, the importance of keeping the operation uniform and at near maximum is obvious. All interruptions, etc., should be localized to include as small a part of the installation as possible.

On account of the connections to the transformers, there has so far always been a mutual electrical relation between two electrodes. But inasmuch as the operation has been found to be somewhat independent at the different electrodes, the question arises whether it would not be advisable to make an arrangement whereby each electrode could really be independent of the other. This could most easily be done by means of a bottom electrode connected to the transformer neutral. Whether this would meet with any practical difficulties, however, must first be investigated. Another advantage of this would be that in case of repairs or when changing electrodes, only one electrode need be disconnected. With a surplus of coal at one electrode the current could be shut off temporarily from this electrode to prevent "hot" operation. A closer and more frequent regulation of the electrodes would then also be possible, thus permitting the highest voltage to be maintained more uniformly.

Electrical Instruments as Guides to the Operator

The electrical instruments serve as a good guide to the operator provided they are connected so that the leads to the furnace have no disturbing influence. Individual measurements at the different electrodes are preferable, and for this reason the instruments should be connected either to the bottom electrode if there is one, or otherwise to some suitable conducting point in the bottom of the furnace. Besides a voltmeter which should be able to be connected between the neutral and the respective electrodes, there should always be a wattmeter for each pair of electrodes, the potential coil of which can be interchanged to different electrodes. By thus carefully following the size of the "working resistance," it would at least be possible to discover in time when there is a tendency for "hot" or "cold" operation and thus make it possible to take the necessary precautions against it. A knowledge of the load on each individual electrode should also give an indication of the limitations as far as the furnace lining is concerned, and it would be highly desirable to have pyrometers installed in the roof near the electrodes if this could be done from a practical point of view. It would then be easy to determine when the electrode should be lowered.

Conclusion

1. The low-voltage leads are of utmost importance as far as the losses and power factor are concerned, and their arrangement should be carefully planned in new installations.

2. The electrical measuring instruments should be arranged so that they will really indicate the electrical conditions at the electrodes.

3. There is an intimate connection between the electrical and metallurgical phenomena at the different electrodes, and an individual control of the electrodes is desirable. It seems that the electrical measurements should be a good guide in determining the metallurgical progress, and for this reason we should endeavor to obtain a deeper knowledge of the relation between the electrical measurements and the metallurgical phenomena. An intimate collaboration between the metallurgist and the electrical engineer is essential in this study of the same, as in the study of the physical character of the arc zone.

Crucible or Electric Steel for High-Speed Tool Steel?

According to the writer of an article in *The Edgar Allen News*, entitled "Crucible or Electric Steel?" electric steel, owing to its purity and comparative cheapness, is admirably suited for many purposes such as constructional parts of motor cars and aëroplanes, miners' drills, blacksmiths' tools, etc., but when it is used solely for producing steel of the highest quality, such as high-speed tool steel, the final word has yet to be said which would place electrical steel in the same class with that of the tried and proved product of the crucible.

Many plausible reasons are given by electric steelmakers for the alleged superiority of high-speed steel made by their process. They claim, for instance, that, as each cast of electric steel is a large one, greater uniformity can be guaranteed than with the crucible process, in which twenty-four crucibles full of steel may be required to make the same weight of steel. But the crucible steelmaker may justly reply that high-speed steel is a very complex alloy; that each constituent, carbon, tungsten, vanadium, chrome, manganese, etc., must be present in exactly the right proportion, or the steel will not be up to the mark; and that in this respect the crucible process is vastly more under control than the electric. Each ingredient being carefully weighed and the crucible sealed, only an accident could alter the composition, and should an ingot be altered in this way it would be readily detected.

Moreover, while one wrong ingot out of twenty-four would not worry the crucible steelmaker, a whole cast of electric steel which went wrong would be a serious business for the electrical maker. If it were only slightly wrong, there would be a great temptation to finish the steel and risk the errors being discovered by the user.

Exaggerated claims of advantages for electric steel should, therefore, according to the writer, not be taken too seriously.

Cooling Liquids in Spray Systems and Cooling Towers

A Description of the Principles Involved in Cooling Liquids—Factors Governing the Capacity of the Cooling System Employed—Data Obtained in Testing the Ceco Spray System—Possible Application of Spray Cooling for Crystallizing Work in Chemical Industries

By EDWIN M. BAKER

IN MANY industries it is frequently necessary to cool hot liquids, either clear solutions or solutions containing suspended solids. Also where a large supply of cooling water for condensers and similar usage is not available, it has become practice to cool the condenser water by some form of spray system or cooling tower, so as to permit using the cooling water over and over again.

The various spray systems and cooling towers all work on the same principle: i.e., they aim to bring the water to be cooled in contact with air, and to effect a cooling of the water (1) by exchange of sensible heat, the water being cooled and the air heated, and (2) by saturating the air with water vapor to cause evaporation of part of the water, thus removing some heat as latent heat. In general, it may be said that the bulk of the cooling is due to the latter effect, but the exact distribution of the cooling may be found only if the entering and exit temperatures of the air and water, and the relative humidity or saturation of the entering and exit air, are known. In any system, if there be no radiation of heat, or if this is so small that it may be neglected, it is evident that the total heat entering in the air and water must equal the total heat leaving in the air and water.

In the following discussion let

t_1 = temperature in deg. F. of entering air.
t_2 = temperature in deg. F. of exit air.
t_3 = temperature in deg. F. of entering water.
t_4 = temperature in deg. F. of exit water.
L_1 = latent heat of steam at the temperature t_1.
L_2 = latent heat of steam at the temperature t_2.
a = lb. of water vapor per lb. dry air carried by entering air, as obtained from wet and dry bulb readings.
b = lb. of water vapor per lb. dry air carried by exit air, as obtained from wet and dry bulb readings.
c = mean specific heat of dry air at constant pressure, in B.t.u. per lb. air per deg. F., taken as 0.2373.
W = lb. dry air entering per minute.
Q = lb. hot water entering per minute.
V = lb. cooled water leaving per minute.

The total heat entering will be the sum of the heat in the water and in the air. The heat above 0 deg. F. carried by the air will be composed of three parts: first, the sensible heat of the dry air, equal to Wt_1c; second, the sensible heat in the water vapor carried by W lb. dry air $= Wat_1$, and third, the latent heat in the water vapor carried by W lb. of dry air $= WaL_1$. The heat carried by the entering water will be sensible heat only, and will equal Qt_3. Therefore the total heat in B.t.u. above 0 deg. F. entering equals $Qt_3 + Wt_1c + Wat_1 + WaL_1$. The heat leaving is likewise, first, sensible heat in dry air $= Wct_2$, second, sensible heat in the water vapor carried by W lb. of dry air $= Wbt_2$, and third, latent heat in water vapor carried by W lb. of dry air $= WbL_2$. The heat leaving by the exit water is Vt_4. Therefore the total heat leaving is $Wct_2 + Wbt_2 + WbL_2 + Vt_4$. Equating these two, we get $Qt_3 + Wt_1c + Wat_1 + WaL_1 = Vt_4 + Wct_2 + Wbt_2 + WbL_2$.

The amount of water entering as liquid equals the amount leaving as liquid plus the amount evaporated, or $Q = V + (b - a)W$. Substituting this value for Q and collecting terms, we get

$$W = \frac{V(t_3 - t_4)}{C(t_2 - t_1) - (b - a)t_3 - aL_1 + bL_2} \quad (1)$$

The amount of cooling due to the sensible heat of the air with the water vapor it carries is $Wc(t_2 - t_1) + Wa(t_2 - t_1 + L_2 - L_1) = W[a(L_2 - L_1) + (t_2 - t_1)(c + a)]$; and the amount due to evaporation and carrying away of sensible heat in this water vapor is $W(b - a)L_2 + W(b - a)(t_4 - t_2) = W(b - a)(L_2 + t_2 - t_2)$.

Therefore the per cent of cooling due to evaporation in terms of the total cooling is

$$W(b - a)(L_2 + t_2 - t_2) \div \{W(b - a)(L_2 + t_2 - t_3) + W[a(L_2 - L_1) + (t_2 - t_1)(c + a)]\}$$

or per cent cooling due to evaporation =

$$\frac{(b - a)(L_2 + t_3 - t_2)}{(b - a)(L_2 + t_3 - t_2) + a(L_2 - L_1) + (t_2 - t_1)(c + a)} \quad (2)$$

Substitution in equation (2) the values found in practice will show in general over 90 per cent of the cooling obtained is due to evaporation of part of the water. Since this is so, it is at once evident that the amount of cooling is practically determined by the evaporation.

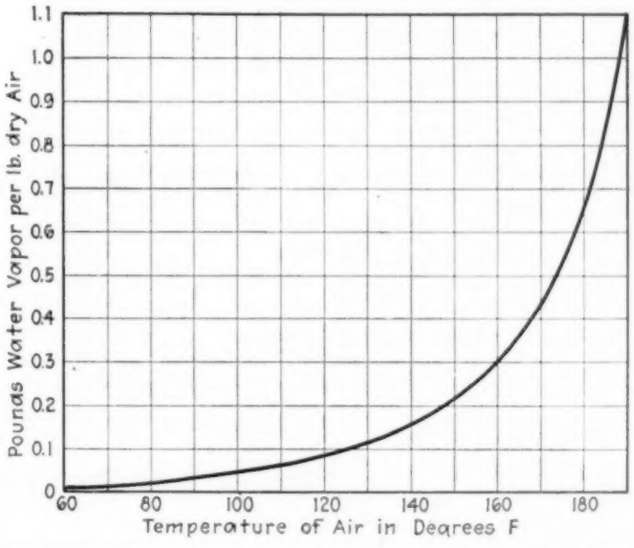
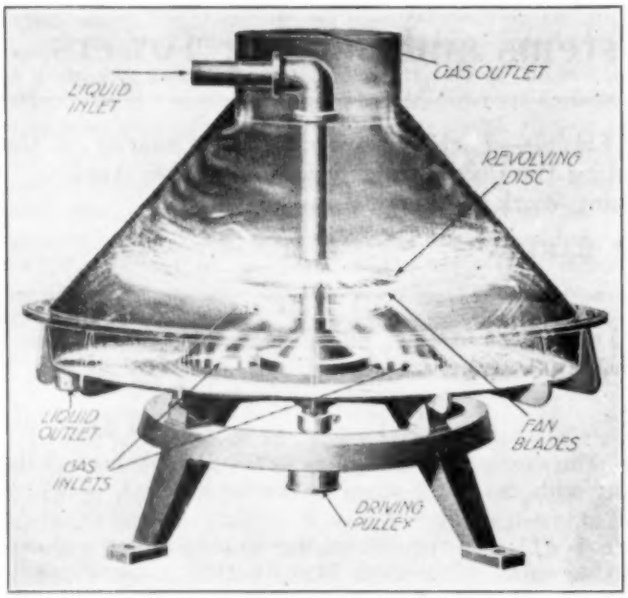


FIG. 1. WATER VAPOR IN SATURATED AIR AT 30 INCHES BAROMETRIC PRESSURE

The term "loss by evaporation," as frequently used in referring to cooling systems, is, to say the least, misleading. The amount of liquid actually vaporized is properly a measure of the cooling capacity of the system. In reality the only way that water can be actually lost in a spray system or cooling tower is by being carried away mechanically as entrainment or spray.



PHANTOM VIEW OF CECO SPRAY SYSTEM IN OPERATION

If the amount of water passing through the system per unit of time is known in addition to the above data, the volume of air handled may be readily computed. The above formula (1) gives the weight in lb. of dry air, and this may be converted to cubic feet at the temperature t, and particular barometric pressure existing. This air will carry with it Wa lb. of water vapor. From steam tables the specific volume of water vapor (steam) at the same temperature and pressure may be found. The product of Wa times this specific volume will give the corresponding cubic feet of water vapor. The sum of the volumes of dry air and water vapor so obtained will give the volume of atmospheric air entering the system. Or, if the air is saturated, the specific volume of the mixture may be obtained from published tables, and the product of $W + Wa$ times this specific volume will give the cubic feet of air.

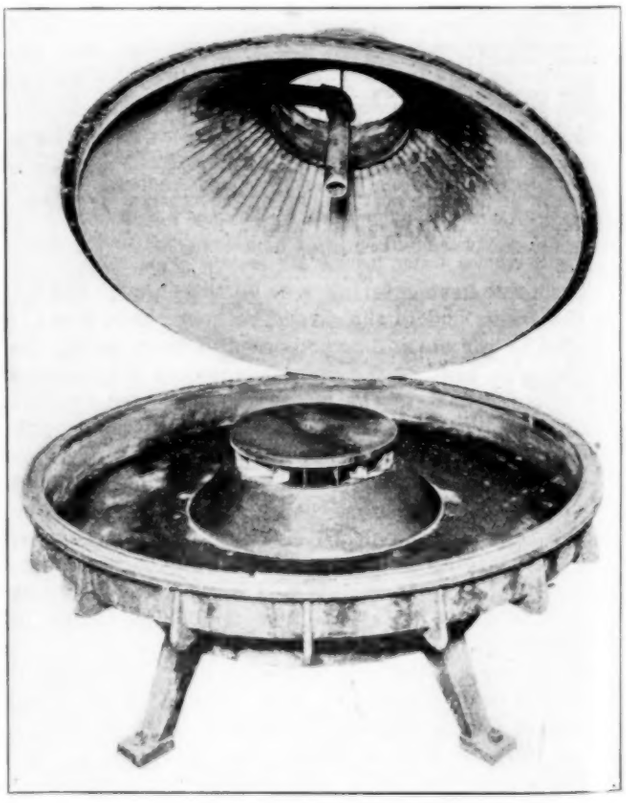
Factors Governing Capacity

The capacity of any cooling system working on air of given temperature and humidity will be dependent on the design of apparatus, the temperature of the exit air, and the amount of air handled.

The design of the apparatus should aim to give complete saturation of the exit air, and to discharge this air at as high a temperature as possible. That is, the counter current principle should be employed, and the intimacy and time of contact between the water and air should be sufficient to cause the maximum possible evaporation.

The temperature of the exit air is of prime importance, as this determines the amount of evaporation that can take place per unit of air handled. Fig. 1 shows the pounds of water vapor carried by 1 lb. of dry air when saturated at different temperatures. The amount of water vapor which can be held by the air at a given temperature is such that the partial pressure of the water vapor in the air just equals the vapor pressure of the water. If less water vapor than this is carried by the air, it is present in it as superheated steam, since it is present at a higher temperature than saturated steam would be at that particular pressure, i.e., the partial pressure of the water vapor. Ordinarily we think of this as merely unsaturated air, or air of a certain per cent humidity. It is not possible for the air to carry more water vapor than that indicated. That is, the exit air cannot be supersaturated unless the temperature is high enough so that the water would boil freely at the absolute pressure existing in the apparatus. For complete saturation of the exit air the amount of evaporation, and hence the cooling effect, will depend on the temperature of the exit air, and will increase very rapidly with increase in temperature. If the exit air is only partially saturated, then it is equally true that the higher the exit temperature of the air, the greater will be the cooling effect.

The cooling effect will always be increased by increasing the amount of air handled, but the increase will be directly proportional to the increased amount of air handled if, and only if, the degree of saturation and temperature of the exit air are maintained constant. However, for a given installation, doubling the volume of air handled will not double the cooling effect, for increasing the amount of air will increase the cooling, and hence the exit air will leave at a lower temperature. So that even if saturated, the air at the lower temperature will carry less water vapor per unit of air, and hence will have caused less evaporation or cooling effect per unit of air handled. It will not be unusual to find that doubling the volume of air will cause an increase in the cooling effect of only 50 per cent instead of the 100 per cent that might have been expected. This may be offset by increasing the flow of water so as to maintain the same high temperature of exit air. In general, the cooling capacity of any system may be increased (as measured by B.t.u. extracted and not by the temperature of the exit water) by increasing the flow of water so as to raise the temperature of the exit air. So, while it would appear contradictory, it is true that



TWELVE-INCH CECO SPRAY WITH COVER RAISED

greater cooling capacity will be obtained with higher temperature of exit water.

Tests on the Ceco Spray System

The writer has had occasion to run some tests on a new type of spray system manufactured by the Chemical Equipment Co. The accompanying cuts show the construction quite well. This spray system tested consists essentially of a revolving disk, carrying radial fan blades on its under side, and housed in a metal cone. The disk is rotated at approximately 1,800 r.p.m., from 2 to 3 hp. being required according to volume of water handled.

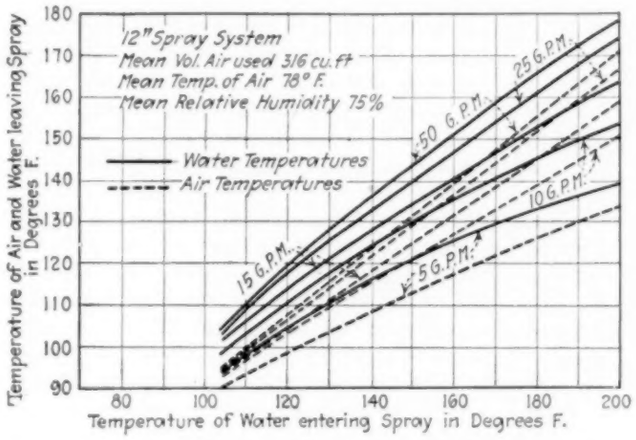


FIG. 2. RELATION BETWEEN TEMPERATURE OF ENTERING WATER AND TEMPERATURES OF EXIT WATER AND AIR

Water, or other liquid to be cooled, is brought upon the center of the disk through a fluid inlet pipe. The liquid is distributed evenly over the surface of the disk, but cannot travel at quite the rate of speed of the disk itself and consequently the liquid is broken up into small drops, each one of which is set spinning about its own axis. These drops, when leaving the disk, also tend to travel about the disk axle, and the combination of the two motions combines to give a planetary motion to each drop. A drop, as it proceeds outward from the disk, will subdivide into finer drops, to each of which is likewise imparted the planetary motion. The finer drops again subdivide, and so on. Thus a liquid curtain is built up in the spray system, thin, but dense near the edge of the disk, and becoming thicker and less dense at the cone wall.

Air is drawn in through the bottom of the spray system and discharged from the fan blades at a velocity slightly less than that of the liquid. The air is so directioned that it and the liquid curtain meet at a small angle, and due to the greater velocity and density of the liquid curtain, the direction of the air is changed without the possibility of its tearing holes in the liquid curtain, and it thoroughly intermingles with the liquid until the cone wall is reached. At this point the liquid is deflected downward, and the air upward. Due to the rotation of all particles about the disk axis, the air in its travel upward takes the path of a long spiral, and because of the centrifugal action, all entrainment is thrown out by the time the air exit is reached. The air is thus discharged from the top of the cone, whose function is to separate out any drops of liquid and so prevent entrainment; while the cooled liquid is discharged from a large connection below the cone.

The spray system was set up in the laboratory so as to permit measuring the volume of water used, the temperature of entering and exit water, and wet and dry bulb temperatures of the entering and exit air. Calibrated thermometers were used. Several sets of cooling tests were made, using a constant flow of water for each set, and varying the initial temperature of the water. Each test lasted about 11 min., ten readings of all thermometers being taken at even time intervals. These readings were averaged, and the proper thermometer corrections applied to get the true readings. From these data and the gallons of water cooled per minute, the volume of air handled and the cooling effect in B.t.u. or deg. F. could be obtained.

Temperature Changes With Varying Flow of Solution

Fig. 2 is interesting in that it shows the actual capacity of a commercial machine with a given volume of air, and as an illustration of the fundamental principles involved. If it were desired to cool large amounts of water for condenser or other work, the most economical operation would be to use a high rate of water flow and several machines in series, each discharging its saturated air separately into the atmosphere. But if it were desired, as in some chemical industries, to cool a small amount of liquid very quickly, a small flow of liquid should be used to give the desired effect, at the sacrifice of capacity. These statements in a qualitative way are general, and applicable to any type of spray or tower system.

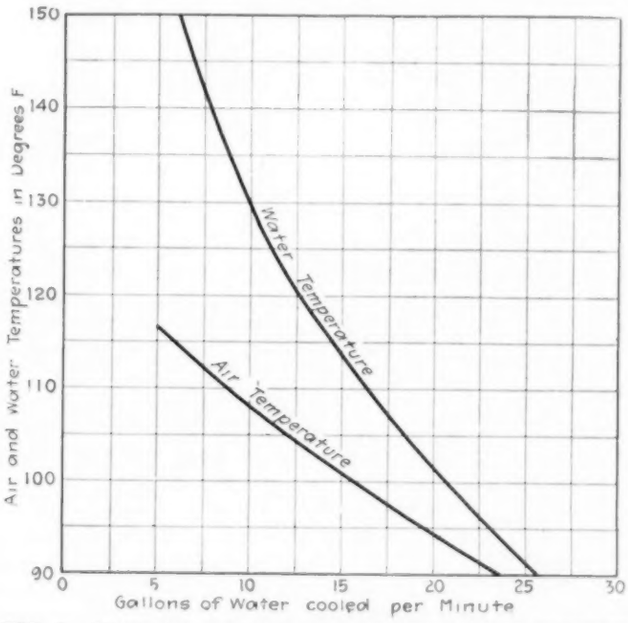


FIG. 3. MINIMUM INITIAL TEMPERATURE AND VOLUME OF WATER REQUIRED TO GIVE COMPLETE SATURATION OF EXIT AIR

Fig. 3 shows the minimum initial temperature and volume of entering water that give complete saturation of exit air. The corresponding temperatures of exit air are also plotted on this curve. For smaller volumes or lower initial temperature of entering water, the air will escape without causing maximum possible evaporation or cooling per unit of air used. To obtain maximum capacity of the machine it should be operated so as to give a saturated exit air, that is, if the initial temperature of the entering water is plotted against the water flow, the point should fall in the area to the right of the curve as drawn. There may be cases, however,

where the maximum capacity is not the main objective, and where for special reasons it would be desirable to operate to the left of the curve, that is, with the exit air not completely saturated.

Effect of Variation of Volume of Air

Fig. 4 shows the effect of increasing the volume of air handled. This was done in these experiments with the aid of a booster fan. The effect is exactly what could be predicted from fundamental considerations.

Another interesting feature brought out by the tests was the resistance of the liquid curtain to passage of the air. It was expected that just as increasing the liquid flow in a tower system increases the resistance to the passage of air, so increasing the water flow would have the same effect with the system under test. The reverse was found true. Increasing the flow from zero up to 60 gal. of water per min. caused a Pitot tube in the air inlet duct to show a marked increase in the volume of air handled. The water undoubtedly exerts a pumping or fan effect on the air—a very interesting characteristic. The tests also showed that there was no liquid entrainment in the exit air for any rates of flow of water and air used.

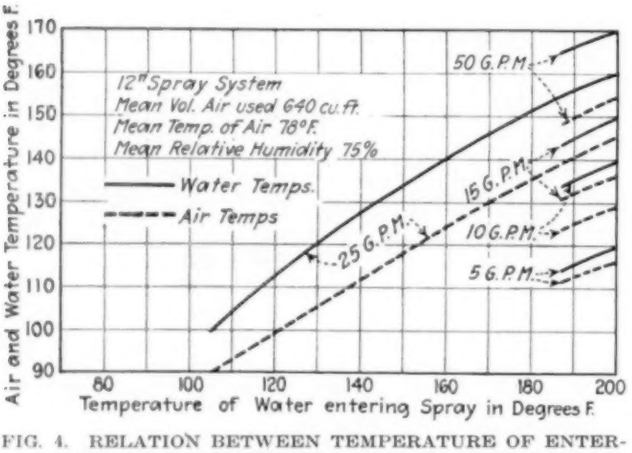


FIG. 4. RELATION BETWEEN TEMPERATURE OF ENTERING WATER AND TEMPERATURES OF EXIT WATER AND AIR, WITH INCREASED AIR VOLUME

The writer is particularly interested in the possible applications of the spray system in the chemical industries for crystallizing work. In many cases, hot solutions are run out into vats to cool slowly, the object being to form large uniform crystals. Large vats are required, and crystals of uniform size are difficult to obtain. Now, if such a solution could be run through a spray system (of a non-clogging type such as the one under test) and rapidly cooled to just the temperature of initial crystallization, and if this were accompanied by violent agitation (as obtained in this case), a large number of very small seed crystals could be started. If this liquid just starting to crystallize and containing many fine seed crystals were run to a vat to stand, the seed crystal should grow with reasonable uniformity, giving a well-graded product of large crystals. The saving in vat capacity, due to the much lessened time required for cooling the liquid with such a system, would be enormous. Moreover, concentration in the particular evaporators used would not have to be carried quite so far, as the evaporation in the spray system would remove a certain amount of water.

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Some Metallurgical Features of the Liberty Engine

By R. S. Archer

THE development and manufacture of the Liberty engine has afforded a most unusual opportunity for the study and correlation of knowledge concerning the materials of engineering construction as applied to gas engines. The design and materials specifications of the Liberty engine were based to a large extent upon the best modern practice, and the building of the engine was undertaken by some of the best manufacturers of this country. This applies not only to the principal contractors who turned out the finished engines, but also to the many manufacturers of parts and accessories.

While most of the metallurgical work connected with the Liberty engine was concerned with parts made of steel, the experience gained with these parts and the general principles regarding the suitability of various materials for definite uses should be of value to those engaged in the production of any material for the building of gas engines. Time is too short to cover any great proportion of the many interesting metallurgical questions that arose during the Liberty program. I shall try to point out what seem to me to be outstanding principles of a general nature, and to cite examples in illustration of these principles.

Specifications and Difficulties in Their Fulfillment

The design and materials specifications of the engine were drawn up with a sort of slogan that the best was not good enough. This was due quite largely to the insistence by many people, both in Europe and in this country, that American manufacturers were not capable of building quality engines. The high standards set up were also influenced by the strictness of the foreign specifications and inspection.

It was not long until experience showed that this rule would have to have exceptions if any quantity of engines was to be produced. One of the first difficulties encountered was the machining of the cylinders. It was necessary to remove about $\frac{1}{2}$ in. of metal from the cylinder wall and the Brinell hardness limits specified were 350 to 400. This made the cylinders almost non-machinable. A similar difficulty was encountered in the case of the connecting rods, the hardness of which was about 300 Brinell, and was even worse than in the case of the cylinders, because this was milling machine work instead of a lathe job.

Lowering of Specified Brinell Hardness

One of the first concessions to the necessities of manufacturing was in the case of the cylinders. A little consideration showed that in the operation of welding the intake and exhaust elbows onto the cylinders, which was done after the cylinders had been finish heat-treated, the top of the cylinders would probably be heated up sufficiently to draw the hardness below the specified minimum of 350. A casual inspection of the welding room was enough to show that at least some of the cylinders were being heated to a temperature which would certainly reduce the hardness in places below 350. In order to test the mechanical strength of the finished cylinders, some of them were fitted with a piston in a tensile testing machine and filled with

soft soap. The bursting load found by this means gave ample assurance that the hardness could safely be reduced. The hardness limits finally established were 217-255. The chief factor governing the hardness was machinability rather than strength.

The next step of importance was the lowering of the hardness of the connecting rods. This change encountered considerably more opposition than the change in the cylinders, both because the manufacturing necessity was not so great and also because the connecting rod was considered a more highly stressed part. The situation as regards machining was rather acute, however, because the number of milling machines required for milling the channels in the connecting rods was rather larger than was easy to obtain at the time.

Some tests were run on soft connecting rods by equipping Liberty engines entirely with soft rods. One set of the usual rods was used which had not received final heat treatment and had a Brinell hardness of only 187. No failures occurred. Another engine was equipped with a set of straight carbon steel rods having a hardness of 250. This engine was also run successfully without any failures. As a result of these tests and of the obvious advantage from the standpoint of production the specified Brinell hardness was lowered from 286-321 to 241-277. This meant a change in the minimum elastic limit from 130,000 to 105,000 lb. per sq.in. No subsequent trouble was experienced as a result of this change.

Changes in Originally Specified Screw Machine Parts

Another change of the same nature, but by far the most difficult of all changes to get past the conservatism at Washington, was the substitution of screw stock for the high grade low-carbon steel which had been specified for screw machine parts. It should be explained that the term "screw stock" usually signifies a low-carbon steel of rather high phosphorus and sulphur content. This high sulphur and phosphorus confer upon the steel the property of cutting freely, although the Brinell hardness is actually higher, and steel of this type is almost universally used for screw machine products. The designers of the Liberty engine did not consider that this material was sufficiently reliable for their purposes and consequently specified a first-class open-hearth low-carbon steel with the phosphorus and sulphur limited to 0.045 per cent. At the same time the limits specified on threads were extremely close. It was found practically impossible to produce large quantities of screw machine parts with the required accuracy of thread from the low-sulphur low-phosphorus steel. Such threads could be produced from this steel if new dies were always available, but the die-producing capacity of the country was limited and very hard pressed, so that it became practically necessary to secure a free-cutting steel. In the face of much opposition the specification was finally changed on a large number of lightly stressed screw machine parts to permit the use of low-carbon steel having a sulphur content of 0.06 to 0.09 per cent, and the situation was greatly relieved.

The changes just noted were probably the most important made and were typical of a number of other changes of a similar nature. These changes were all an expression of the general tendency to specify a material which could be manufactured into the necessary parts, rather than one which would be ideal if it could be manufactured.

As time went on and the cry for increased production of engines became more insistent, further changes in material were made to facilitate manufacture, although they were not of so urgent a nature as the above changes. The time had been reached when such changes could be safely made, because the engine was much better understood, and the original factors of safety which had been employed, which were largely factors of ignorance, could be reduced. Two changes in materials of this type were the substitution of chrome-vanadium steel for chrome-nickel steel for connecting rods, and the substitution of a steel of reduced nickel and chromium contents for the crankshaft. The high chrome-nickel steel originally used for the connecting rods is particularly difficult to handle, especially in the forging and heat-treating operations. This is due to a large extent to the fact that nickel decreases the welding power of steel, thereby causing cracks once formed to remain open, and to the semi-air hardening properties of the steel which cause it to stiffen up severely if allowed to cool to too low a temperature during the forging operation. The connecting rod problem became so serious that in May, 1918, connecting rods had become the proverbial "neck of the bottle." At least this was said to be the case, and at a conference of the American Drop Forgers' Association it was decided to substitute a chrome-vanadium steel. This was done by most of the manufacturers. The result of this change was a faling off within six weeks of the average forging scrap on connecting rods from about 55 per cent to less than 10 per cent.

A change of the same nature was the substitution of S. A. E. steel 3240 for X3335 for crankshafts, because of the greater ease in forging and heat treating and the greater freedom from defects arising from the original steel ingot.

Tendency of Specification Changes

The tendency exemplified by these changes in material and lowering of the physical properties required seems to be characteristic of modern engineering thought and may be summed up in this way:

First, there is no use in specifying a material for production work which cannot be produced with the manufacturing facilities available.

Second, and rather more important because less obvious, is the tendency to prefer uniformity and reliability of product to a less uniform and less reliable product, which may have superior properties when it is at its best.

Significance of Manufacturing "Scrap"

There has been a rather inadequate appreciation of the engineering significance of manufacturing "scrap." It has pretty generally been considered that a high percentage of scrap simply means high cost and occasionally insufficient production. The evils of scrap material go much further. Scrap is material containing defects which have been found. A high percentage of scrap means a high percentage of detectable defects, and *implies* a high percentage of defects which are not detected. This may be illustrated by a consideration of the Liberty connecting rod. Most connecting rods were first made of S. A. E. steel, X3335 or X3340. These are steels containing approximately 3 per cent nickel, 0.80 per cent chromium with 0.35 and 0.40 per cent carbon. As mentioned before, this steel is difficult to handle in every step of its manufacture.

This includes the melting, casting, rolling, forging and heat treating. The defects arising from the difficulties encountered in the steel mill are typified by the snowflakes and hairline seams found in the finished stock. In forging, the steel is very sensitive to burning if it is slightly overheated. It also cracks quite easily and has the property of not welding shut on further application of work. These properties result in the production of a high percentage of scrap forgings, meaning forgings in which the defects are visible. The same causes which produce these visible defects also produce a correspondingly high percentage of invisible defects which are difficult to detect. In order to detect overheating it was required that small lugs be forged on the side and end of each connecting rod and that these be broken off after the final heat treatment in order to test for the coarse grain characteristic of overheated steel. These lugs could not, however, vouch for the quality of the entire rod, especially of the thin section in the channel, which was very apt to be overheated in the operation of heating up the big end of the rod. Similarly, the minute cracks formed occasionally in forging were sometimes completely hidden and there was no way of finding them in the finished connecting rod. When the change was made to chrome-vanadium steel, in spite of the fact that chrome-vanadium steel at its best is inferior to chrome-nickel steel at its best, it is very probable that the percentage of inferior rods which passed the final inspection and went into engines was less than when the chrome-nickel steel was used.

This is merely one example of a principle which applies to any manufactured article; that is, the greater the percentage of apparently perfect material that can be produced, the greater will be the percentage of truly perfect material and the less will be the probability of hidden defects.

Uses and Abuses of Alloy Steels in the Art of Producing Engineering Materials

This principle is not as yet widely accepted by the engineering profession, but that its acceptance is growing is shown by an increasing tendency to specify straight carbon steels where alloy steels were formerly used, not in order to cheapen the product, but to improve its quality. It is still true that alloy steels, some of them of a very fancy composition and with very extravagant claims made for their properties, constitute a strong selling point for the steel salesman, but I believe the tendency is against these products in favor of a product which can be made with greater uniformity and certainty. This does not mean that it is advisable to avoid alloy steels or other materials of a superior quality simply because the methods of fabricating them have not been fully developed. Such an idea would of course stifle advances in the art of producing engineering materials, nevertheless there are some materials which are inherently more difficult to produce satisfactorily than others. For example, I do not see how any advance in the art of manufacturing alloy steels can overcome the fact that nickel steel is difficult to weld and that cracks once formed in a forging will remain open; or, to go even farther back than this, that cracks formed in the ingot will also remain open and be found in the finished product as snowflakes or other defects. The alloy steels must by all means be used where material of the very highest properties is necessary. There are also cases where economy requires the use of alloy steels because of the wider range of heat-treating temperatures, and the greater ease of machining.

Strength of Materials

Let us consider briefly the steps in engineering design, as applied to the strength of materials. First, the maximum working stresses of the part in question are calculated; a factor of safety is assigned and a material chosen whose properties are expected to give the required factor of safety when the part is made of the proper dimensions. This method, which is followed so largely in structural engineering, does not hold to such an extent in automotive design. In building automobile engines and especially airplane engines, the practice has been to start with a part of sufficient size and made of a material of sufficient strength to give considerable assurance of safety, then to gradually reduce the dimensions of the part or the physical properties of the material to the lowest point which experience shows to be safe. I have been told that one of our foremost designers of airplane engines determined the limiting sizes of his important parts by running destruction tests on engines containing parts of successively smaller dimensions. When the dimensions had been reduced to such an extent that the part in question failed in service, it was known that the dimensions had to be increased or a better material used. In other words, the engineering of automobile and airplane engines has been largely a cut-and-try proposition.

Factors of Safety

The factor of safety which is used in engineering design is largely a factor of ignorance; ignorance as to the actual stresses developed in service, and ignorance concerning the true physical properties that will be obtained in the fabricated part. The nature and extent of the working stresses developed are investigated by the process of cut and try to which I have referred. By this process there is obtained a fairly exact idea of the limiting dimensions of the part, assuming definite physical properties in the material to be used. These minimum dimensions must then be increased in proportion to the uncertainty regarding the physical properties which actually will be obtained. This uncertainty, and consequently the dimensions and weight of the part in question, can be reduced by using a material which is more certain to yield uniform properties and less likely to develop flaws which are hard to detect in inspection. It is not the average physical properties of the material of a given piece of mechanism that determine the quality of the machine, so much as it is the maximum deviation from the average. For example, it may be better engineering practice from the standpoint of quality alone to use a straight carbon steel with an average elastic limit of 90,000 lb. per sq.in., in preference to a chrome-nickel steel having an average elastic limit of 125,000 lb. per sq.in., if the conditions of manufacture are such that the percentage of parts made of the straight carbon steel which fall dangerously low is less than the percentage of the chrome-nickel steel parts which fall dangerously low.

Conclusion

To sum up the foregoing observations, the effect of the Liberty engine program upon the selection of engineering materials has been to emphasize the importance of uniformity of product and ease of manufacture.

Loss Due to Carbon in Furnace Refuse*

By C. H. Berry

IT IS common to treat as pure carbon the combustible which passes through the grates or over the dump plates together with the ash. The losses resulting from the failure to burn this lost coke depend upon two factors—the percentage of ash in the original coal and the percentage of carbon in the furnace refuse. Both of these quantities are determined by laboratory analysis of samples of the coal and refuse respectively. Knowing these values, the heat loss may be computed from the following equations:

$$\textit{Per cent ash in refuse} = 100 - \textit{per cent carbon in refuse.}$$

$$\textit{Lb. refuse per lb. coal} = \frac{\textit{per cent ash in coal}}{\textit{per cent ash in refuse}}$$

The weight of carbon lost is then

$$\textit{lb. refuse per lb. coal} \times \frac{\textit{per cent carbon in refuse}}{100}$$

$$= \frac{\textit{per cent ash in coal}}{\textit{per cent ash in refuse}} \times \frac{\textit{per cent carbon in refuse}}{100}$$

This may be written:

$$\textit{Lb. carbon lost per lb. coal fired} = \frac{\textit{per cent ash in coal}}{100} \times \frac{\textit{per cent carbon in refuse}}{100 - \textit{per cent carbon in refuse}}$$

Since 1 lb. carbon has a heating value of 14,600 B.t.u.,

$$\textit{Lb. carbon lost per lb. coal fired} \times 14{,}600 = \textit{B.t.u. lost per lb. coal fired.}$$

The percentage heat lost will be

$$\frac{\textit{B.t.u. lost per lb. coal fired}}{\textit{Heating value of coal as fired}} \times 100.$$

These formulas have been combined in the accompanying alignment chart, in which the left half gives the pounds of carbon lost per pound of coal and the B.t.u. lost per pound of coal, for given values of the percentage of ash in the coal and the percentage of carbon in the refuse. The right half of the chart gives the per cent of heat loss from the known result found from the left half of the chart together with the known heating value of the coal.

An examination of the chart will indicate that the extent of this heat loss may be considerable. For example, if we fire a coal containing 12.5 per cent of ash, and if the resulting furnace refuse contains 38.7 per cent of carbon, the weight of carbon thus lost will be 0.079 lb. of carbon per pound of coal fired. This results in a loss of 1160 B.t.u. per pound of coal fired. If the heat value of the coal is 12,700 B.t.u. per lb. this heat loss will be 9.2 per cent of the heat value of the coal, which is the basis used for figuring all the heat losses in the furnace, boiler and setting. It can readily be seen that for higher percentages of carbon in the refuse this loss may be an even larger proportion of the heating value of the coal. It should also be noted that a higher ash content of the coal, with the same percentage of carbon in the refuse, will also give a larger heat loss. This is one reason, though a minor one, why high-ash coals do not permit as high boiler efficiencies as obtainable with higher grades of fuel.

The extent to which this loss may be reduced depends upon many things, but it seems that under fair operating condtions it is reasonable to expect not more than 20 per cent. of carbon in the refuse, and under good conditions not exceeding 10 per cent. The corresponding heat losses will then be less than 5 per cent and may be as low as 1 per cent under favorable conditions. A series of 77 tests conducted at the St. Louis plant of the United States Geological Survey showed an average heat loss a little under 5 per cent, and these tests were made under oprating conditions, using coals of a wide range of quality.

Practical suggestions for reducing this loss include: Avoidance of unnecessary barring and raking of fires, an ample (but not too vigorous) supply of air at the dump plate, and the use of clinker grinders.

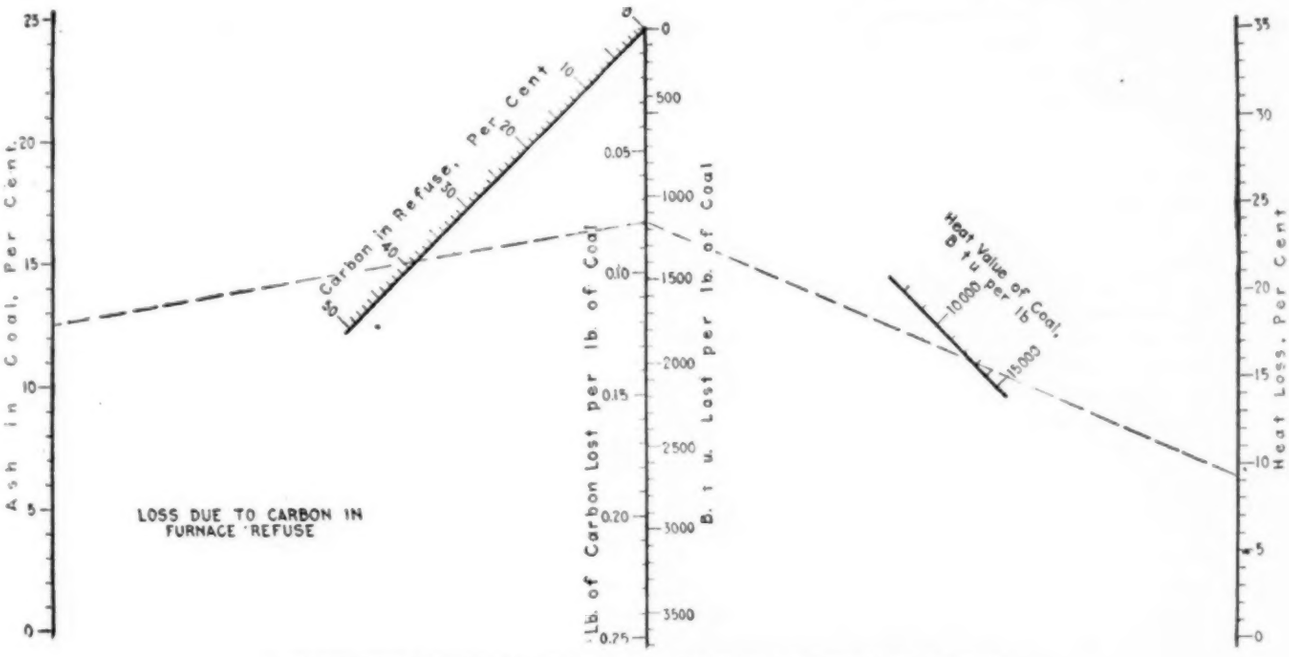

Ash in Coal, Per Cent.
Carbon in Refuse, Per Cent
Lb. of Carbon Lost per lb of Coal
B. t. u. Lost per lb. of Coal
Heat Value of Coal, B.t.u. per lb.
Heat Loss, Per Cent
LOSS DUE TO CARBON IN FURNACE REFUSE

CHART FOR FINDING LOSS DUE TO CARBON IN FURNACE REFUSE

*Abstracted from *Power*, Sept. 23, 1919, p. 500.

Legal Notes

By Wellington Gustin

Unfair Competition by Use of Trade Mark—Extent of the Use of Trade Mark

THE rights of one to adopt and use names in the prosecution of one's business is very broad, but must be limited when such use injures the business of others. Especially when the use of a word offers unfair competition with another who has a prior right to its use the courts will interfere to protect the latter's interests. But the right to exclusive use of a trade mark is not unlimited. In a recent case at special term the Supreme Court of New York County enunciated several rules affecting these principles. (177 N. Y. S., 713.)

The plaintiff in the case is a trading corporation organized in 1907, at that time succeeding to the business of a partnership formed in 1900. It is chiefly engaged in trade with foreign countries, dealing in a great variety of merchandise, paper products appearing to be its chief lines. It seems to be rapidly extending its lines and business and is the owner of a trade mark, consisting of the word "Caravel" with the picture of a sailing vessel of the ancient type. This word was originally used only on paper, but as the business was expanded the trade mark was more widely used, so that it has been affixed to inks, ink-making materials, and various other goods. Other goods have been shipped and to them the word has been applied as a designation of a brand in the invoices. Goods of many other descriptions have been shipped, and many other shipments of similar goods have been made without the use of either the name or the mark.

Name Complained Of Chosen Innocently

Now, in 1916 the defendants in this case formed a partnership and began doing business under the trade name "Caravel Company." The firm name was chosen innocently. At first the firm business was confined to dyestuffs, but later it dealt also in drugs and chemicals. Its business also was largely done with foreign countries. In 1918 the defendant corporation was formed and the firm name was adopted as the corporate name. The business of the firm was transferred to the corporation and the firm dissolved. The partners became officers of the corporation, which continued the business in dyestuffs, drugs, and chemicals. It also extended its dealings to general merchandise. It has used a label upon which its corporate name is printed, together with a representation of a sailing vessel of the caravel type. The catalogs, advertising matter, and stationery bear the same name and drawing. Its label has been affixed to certain classes of goods which plaintiff has been accustomed to ship without its trade mark. It was shown to have attempted to do business in paper and in other classes of merchandise which plaintiff had dealt in previously under its trade mark. Prior to the organization of the corporation, but after the formation had been decided on, plaintiff notified the firm that it was the owner of the Caravel trade mark and requested the firm to discontinue the use of the word "Caravel," both in its firm name and otherwise, in connection with the sale of its goods. At this the firm had a search made of the records of the Patent Office. This search showed the particular classes of merchandise for which plaintiff's trade mark had been registered, and also that trade marks consisting of the word "Caravel," both with and without the representation of a sailing vessel, had been registered by other persons for goods of various descriptions. The defendants refused to abandon the use of the name "Caravel Company" or the use of their labels, and plaintiff asked for an injunction against them.

The essence of the wrong complained of is unfair competition, said the court. The general principles applicable were stated as follows: "A trade mark is acquired by adoption and use as such. It must be affixed to the goods. The right of user is in its very nature an exclusive right. Unauthorized use or imitation by a competitor may be restrained. The right to exclusive use of the trade mark is not unlimited. Its use upon one or more commodities does not give the right to use it upon all. But neither is the right confined to the precise species of goods to which the mark has been affixed. It extends to other goods of the same class; and where the general uses or characteristics of the articles are similar or analogous they are within the same class. A trade mark used by a manufacturer of picks and hoes may not be used by a competitor upon shovels; . . . nor may a manufacturer of tooth brushes appropriate the mark used by another on hairbrushes.

Test of Legal Trade Mark

"Prior appropriation to the species prevents a subsequent competitive use upon a class in which the species is included. The test is whether an intending purchaser would be likely to mistake the origin of the goods. The purpose is to prevent the palming off of the products of one trader as that of another; and where the danger of confusion and deception is manifest, it is unnecessary to prove that either has in fact occurred. The principles thus stated as applicable to trade marks apply equally to marks which are not technical trade marks and to trade names. So the use of a corporate name may be enjoined, if confusion or deception is likely to result from its use by a dealer in competitive goods."

Applying these principles the court concluded:

First—The plaintiff has acquired the exclusive right to use the Caravel trade mark on the various classes of goods upon which it or its predecessor was the first to affix and use that mark.

Second—The plaintiff did not acquire any exclusive right to the use of the name or mark by the mere use of the name "Caravel" in its invoices.

Third—The use of the trade mark upon certain classes of goods cannot upon any theory of extension of user give to plaintiff the exclusive right to use it upon all the varied classes of general merchandise in which it has dealt, or in which it may hereafter choose to deal.

Fourth—Though the use of a corporate name may be restricted and enjoined in a proper case, there is no ground upon which the defendant company can properly be required to discontinue the use of its corporate name.

Whether the defendant corporation should be allowed to do business in its corporate name in those classes of goods upon which plaintiff has the exclusive right to use the Caravel trade mark was an important question in the case. The court said that if

the business of the defendant corporation was confined solely to such goods, it would be restrained from doing business under the name "Caravel Company." But the defendant corporation deals in goods of a very diversified character. Hence the court held that defendants should be restrained from dealing in or advertising, under the name "Caravel Company" or any other similar name, those goods as to which plaintiff has established the exclusive right to use the Caravel trade mark. So judgment was given accordingly.

Injuries to Workmen From Noxious Dust and Gases —Employer's Duties Set Forth

Compensation acts are disposing of much of the negligence cases formerly arising under the common law. However, exceptions and conditions still permit of many cases. In Indiana, which has such an act, comes a case wherein an employee brings an action against his former employer to recover damages for injuries to his eyes and health through the employer's negligence in permitting the escape of noxious dust and gases from its mixing room into the room where the employee was working. (Brunson vs. Macbeth-Evans Glass Co., 122 N. E., 438.)

From the facts it appears that the employment extended over several years and the injuries were a general resulting condition some time after the employment. In this complaint the plaintiff charged that he first worked for defendant as a gatherer of molten glass and later as a glass blower, working in the blowing room; that adjacent to the blowing room defendant maintained a room known as a mixing room, where it mixed products used in the manufacture of glass in large troughs; that among the poisonous substances thus mixed were suboxide of copper, oxide of tin, white sand, pearl ash, saltpeter, arsenic, magnesia, soda ash, lime, carbonate of soda, niter, charcoal, and lead, which said substances were at all times mixed dry; that all of these substances were injurious to human beings who came in contact with them, and were especially injurious to the eyes of such persons. The plaintiff further charged that from the mixing of these poisonous substances in a dry and powdery state, there arose a cloud of dust, which, if not confined and prevented from blowing from the mixing room into the other rooms of the factory, would permeate the air of these parts and injure the eyes and eyesight of the workers there; that during the time of his working in the blowing room his eyes and eyesight became affected and injured from this dust, though at the time he did not know that they were, or would become, injured from it.

The defendant was charged with knowledge, or by the exercise of proper care should have known, of the injurious and deleterious effect of this dust upon the eyes of human beings. It was charged with negligence in that there were doors in the mixing room for the purpose of keeping it closed, but defendant permitted the doors to be open and the dust to escape through these doors into the blowing room, where plaintiff worked; that defendant negligently suffered the partition shutting off the mixing room to be loose and insecure and allowed large cracks and openings to remain in the same so that dust and gases from the mixing troughs and poisonous chemicals escaped into the blowing room and into the plaintiff's eyes and face. All of which injured plaintiff's general health and his eyes and caused cataracts to form over them, permanently impairing his eyesight.

In another count of the complaint negligence was charged in that the employer did not instruct the employee as to the danger to his eyes when they were, as during the course of the employment, exposed to intense radiated heat.

Another count was the alleged negligence of defendant in causing plaintiff to work exposed to great heat, when run down physically.

Plaintiff obtained a verdict and judgment for damages upon the trial. On appeal the higher court held the complaint stated a good cause of action, but granted defendant a new trial on an erroneous instruction regarding defendant's allowing plaintiff to work where his eyes were being subjected to radiated heat while in a run-down physical condition.

It should be valuable to employers to know what the court said regarding the first cause of the complaint. The duty of the employer in protecting his workmen is put into a statute that is more than declaratory of the common law. This statute provides as follows:

Statute Defines Employer's Duties

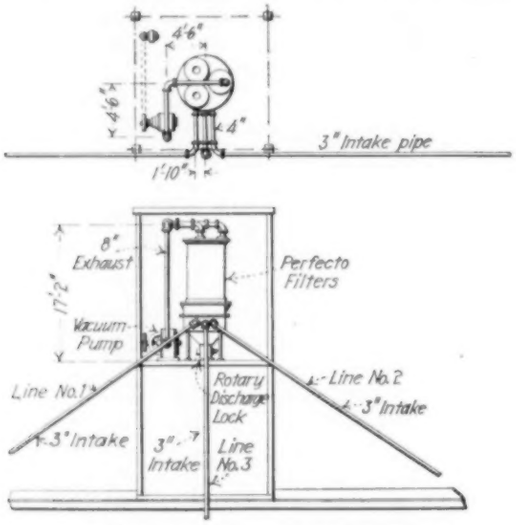
"It is hereby made the duty of all owners, . . . corporations, agents or persons whatsoever, engaged in the care, operation, management, . . . of any shop, factory or business of whatsoever kind, . . . and generally it shall be the duty of all owners, managers, operators, contractors, . . . and all other persons having charge of, or responsible for, any work, mechanism, machinery, appliance, building, factory, plants, means, employment, or business of whatsoever nature, involving risk or danger to employees, . . . to use every device, care and precaution which it is practicable and possible to use for the protection and safety of life, limb and health, limited only by the necessity for preserving the reasonable efficiency of such structure, ways, work, plant, building, factory, . . . appliances, apparatus, or other devices or materials, without regard to additional cost of suitable materials or safety appliances, or safe conditions or operations, the first concern being safety to life, limb and health."

In view of this statute the court asked: Did the defendant "know that the continued breathing of the dust and fumes as complained of was injurious to the workmen? If it did not so know, could it, by the exercise of reasonable care and caution in the premises, have so known? If it did know of the poisonous nature and deleterious effect of these gases and dust on workmen, and permitted their continued exposure thereto, it was negligent, as a matter of law. . . . If it did not have actual knowledge of the foregoing facts, but by the exercise of reasonable care in the premises could have so known, and yet permitted the continuation of such dangerous condition, as to which condition the jury were told in said instruction that they must find as a fact 'that said partition was allowed by defendant to become in disrepair, and was not properly constructed, and that doors and windows were left open so that dust was allowed to arise and blow through said crevices and cracks and said doors and windows in said partition, into and upon the workmen and the plaintiff, at work in said blowing room,' then, this fact being found against defendant, it was guilty of negligence in not so ascertaining that fact, and in permitting further unnecessary exposure of its employees thereto."

Dracco System at Armour Fertilizer Co.

The accompanying illustration shows the operation of a Dracco nozzle directed by a single workman in removing dry blood, tankage, and other materials used in the manufacture of fertilizers at the Jacksonville plant of the Armour Fertilizer Co. Formerly cars were unloaded by hand and material lifted by bucket elevators, a process most tedious and unsanitary and at the same time expensive.

Three ascending intake pipes terminate at the lower end in flexible steel hose, and intake nozzles make it possible to unload three cars without switching. These steel pipes lead upward to and are connected with a receiver where all the coarse particles are settled, this



OPERATION OF A DRACCO NOZZLE

settlement being accomplished by a reduction in the air velocity.

The extremely fine dust passes upward into filter units of the Perfecto type, placed directly on top of the receiver. This settling and filtration collects all the material and it is carefully discharged through an especially designed rotary lock as fast as unloaded. The air which has been entirely cleaned by its passage through the filters is sucked through a high-efficiency vacuum pump. Operation depends upon a high vacuum, which may be anywhere from 5 in. to 25 in. of mercury according to distances, material, capacity, and other local conditions.

Scoop Conveyors for Coal Storage

A portable conveyor developed by the Portable Machinery Co., Passaic, N. J., shown in Fig. 1, has become quite popular as a means of handling bulk materials from car to wagon or stock pile, or vice versa.

A great advantage of using the scoop conveyor to

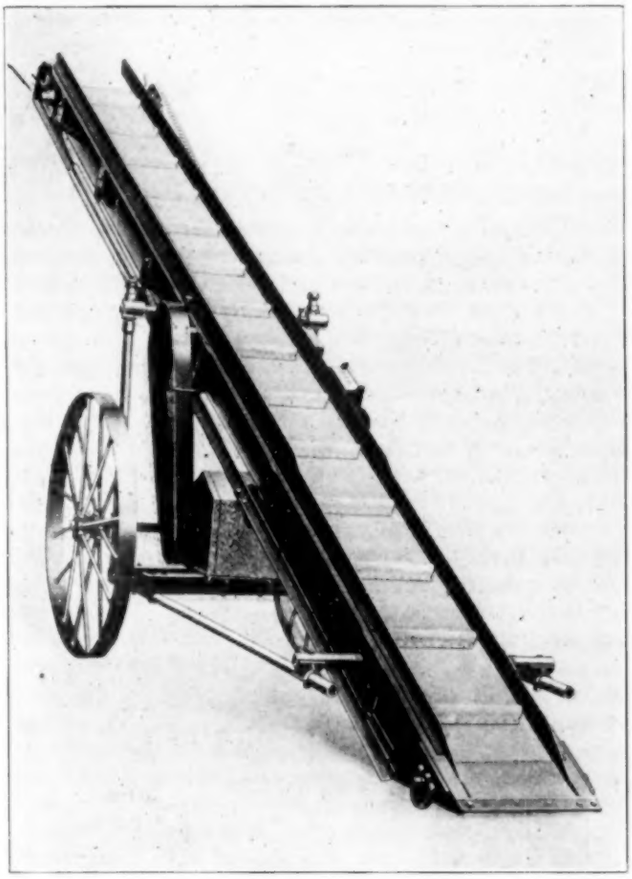


FIG. 1. SCOOP CONVEYOR FITTED WITH HIGH-FLIGHT BELT

unload hopper-bottom cars is the fact that no track hopper or pit is necessary. This makes it possible to unload cars at any point along the track. To unload a car, the feed end of the machine is placed near or under the car hopper, which is then released and the belt on the conveyor carries the material away as fast as it flows through the hopper opening.

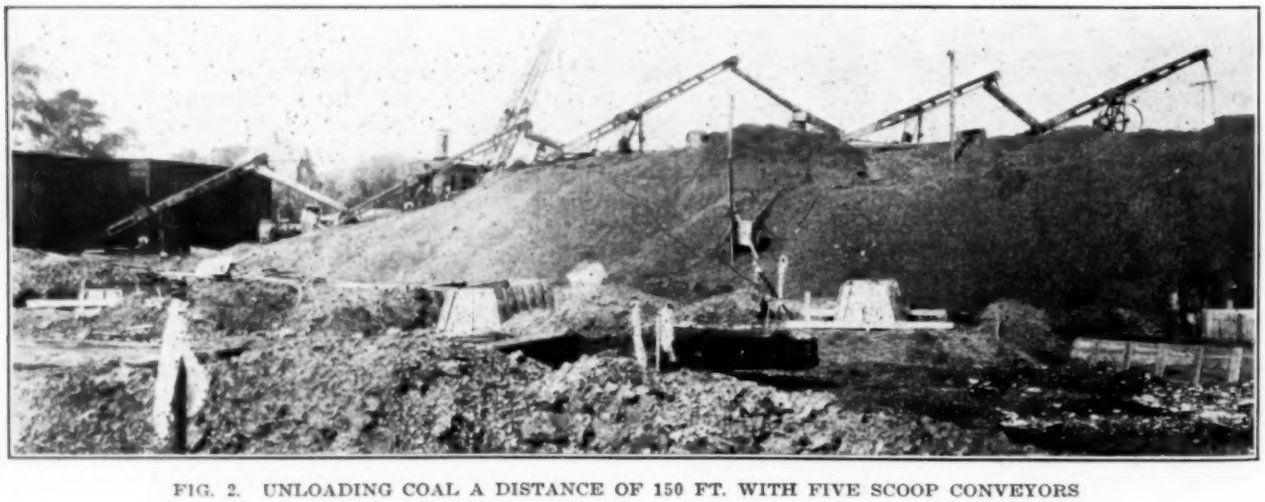


FIG. 2. UNLOADING COAL A DISTANCE OF 150 FT. WITH FIVE SCOOP CONVEYORS

An interesting application for storing coal is shown in Fig. 2, illustrating five individual machines electrically driven being used to unload coal from hopper-bottom cars direct to storage pile. This provides a convenient, efficient and flexible arrangement. The first

FIG. 3. LOADING COAL HOPPER ON A HUNT ELECTRIC STORAGE BATTERY TRUCK WITH A SCOOP CONVEYOR

machine is practically self-feeding from the hopper doors of the car, and the four others may be swung around at any angle to cover a wide storage area, and can be operated by one or two men. They can also be used to reverse the operation and convey the coal direct from storage pile into boiler room, or singly to load as shown in Fig. 3.

Synopsis of Recent Chemical and Metallurgical Literature

The Solubility of Gold in Cyanide Solutions.—A paper on this subject, by A. H. WHITE, was published in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa for July, 1919, of which the following is an abstract:

The relative rate of solubility of gold and zinc by cyanide solution is proportional to their equivalent weights; thus

$$2Au : Zn = 394.4 : 65.37 = 6.03$$

Maclaurin has also found the relative rate of solubility of Au and Ag is proportional to their atomic weights.

The speed of the reaction depends entirely upon the rate of diffusion of the cyanide and oxygen in the solution in practice, of which the latter is the more important. The final effect of the reaction is given by the equation

$$2Au + 4KCN + O + H_2O = 2KAu(CN)_2 + 2KOH$$

394.4	260.44	16.0
1.000	0.6603	0.04057
1.5145	1.000	0.06144
24.648	16.276	1.000

Therefore 10 mg. oxygen per liter is equivalent to 0.0163 per cent KCN, 7 mg. to 0.0114 per cent KCN and 6 mg. equivalent to 0.0098 per cent KCN in solution. Since the average concentration in this district is 6 mg. of oxygen per liter, other things being equal, there is no advantage in maintaining the cyanide strength of the working solution in excess of 0.01 per cent KCN. It was found by experiment, however, that with about 6 mg. of oxygen per liter, the greatest speed of the reaction was with solutions containing between 0.02 and 0.03 per cent of KCN; sodium cyanide of equivalent strength being used, and the gold being free from electrolytic contact. Maclaurin found the maximum speed to take place at 0.25 per cent KCN; these results are only one-tenth this strength, but are confirmed by the fact that a similar degree of concentration, namely, 0.02 to 0.03 per cent, was found to give maximum speed of reaction for zinc, pure gold and for battery bullion in a solution made up with sodium zinc cyanide, the "total" cyanide strength being taken. There seems, therefore, to be no adequate reason for maintaining higher strengths of solution in contact with sand under treatment where the last portions to yield a profit have chiefly to be considered, and these may well be assumed to be in contact with quartz only. Adequate oxygen concentration is always of an advantage, especially in case of working solutions where side reactions are effective competitors for this oxygen.

The paper contains details of the experiments from which these deductions are drawn, together with tables and curves showing results.

Powdered Coal in the Chemical and Allied Industries.—The *Catalyst* of December contains the following abstract of an address delivered by W. H. FITCH before the Delaware Section, American Chemical Society.[1]

The steel and cement industries are the greatest users of powdered coal as a fuel. Altogether about 2,000,000 tons of powdered coal are used annually. In the steel industry open-hearth furnaces are the greatest users of coal, and there are about eighty-five furnaces thus equipped. About 75 to 80 per cent of the cement produced in the United States is made in the Lehigh Valley, and in this valley nearly all of the kilns are equipped to burn powdered coal. Most of these powdered coal plants have been put in during the last four years. Any kind of coal may be used, from lignites to anthracites. Even anthracites containing as high as 40 per cent non-combustible matter can be thus burned. Lignites must be dried to a water content of 4 or 5 per cent, bituminous coals and anthracites to less than 1 per cent. This drying is necessary to get economical grinding.

When powdered coal was first introduced everybody was afraid that great explosion risks would result therefrom. This has been demonstrated not to be the case, and the bugbear of those unfamiliar with powdered coal is now the ash problem. In regenerative furnaces this really constitutes a problem because the ash deposits in the brick checker-work. With a properly designed furnace, however, this is not serious. In a steam plant burning powdered coal about 10 per cent of the ash known to be in the coal deposits in a molten condition in the bottom of the combustion chamber. Beyond the bridge-wall a further small deposit is found, and in the rest of the setting no more than would be the case when firing coal with a mechanical stoker. The remainder, about 90 per cent, goes up the stack in a finely divided condition.

This is not surprising considering that the coal is ground so fine that 95 or 96 per cent goes through a 100-mesh sieve, 85 per cent through a 200-mesh sieve, and 72 to 75 per cent through a 300-mesh sieve. Powdered coal delivers from 25 to 30 per cent more of the heat value of the coal than gas producers and the installation and operating cost are about half as great as for gas producers. At the present time the total cost of delivering one ton of coal from the railroad

[1]The *Catalyst*, vol. 4, No. 10, p. 4, December, 1919.

siding, grinding it, and preparing it for burning in the pulverized form is about 60c.

Effect of Inclusions on Stress Distribution.—Considerable study has been given to stress distribution in non-uniform sections, notably to the effects of circular holes in tension members. Such variations were experimentally determined by Wilson and Gore using perforated rubber sheets, by Andrew McCance (*Trans.*, Inst. of Eng. and Shipbuilders in Scotland, vol. 62), plotting lines of equal hardness in permanently deformed metal, by E. G. Coker, *Trans.*, Inst. of Naval Architects, 1911; *Proc. Phys. Soc.*, London, vol. 25; *Proc.*, Inst. of Automobile Engineers, November, 1917, and *Trans.*, Inst. of Eng. and Shipbuilders in Scotland (December, 1919), studying interference figures by polarized light on transparent nitrocellulose sheets. McCance also suggests that since a piece is cooled when tension is applied, modern pyrometry, capable of measuring accurately within 0.001 deg., could be used to map lines of equal stress. C. E. Inglis has worked out a purely mathematical solution for both circular and elliptical holes in plates of infinite width (*Trans.*, Inst. of Naval Architects, 1913).

These researches show the surprising result that the dimunition of the section of a bar by a center hole is accompanied by a dimunition of stress at the outer edge of the perforated bar, owing to the great concentration of stress at the boundary of the hole. Stress at the latter point varies widely, from a value practically equal to 3 times the average on the transverse diameter, diminishing to zero at 60 deg. and to a maximum compression at the axial diameter. Intensity of these stresses at the inner edge of the hole is independent of the size of the hole, and the area surrounding subjected to higher stresses than the average is shaped like a two-bladed propeller, with a greatest width extending at right angles to the direction of stress of about 4 times the diameter of the hole.

McCance, in discussing Coker's latest paper in the *Transactions* of the Institution of Engineers and Shipbuilders in Scotland, December, 1919, points out the metallurgical applications of these results. Steel, no matter how well made, always containes non-metallic inclusions, and it has been found by experience that when fracture takes place its path nearly always favors segregated areas. But so long as the impurities are small and uniformly distributed, they do not seem to affect the steel, but when they are large or in clusters or segregates, they are dangerous, causing test pieces to break with low contraction and elongation. Apparently, if the particles are separated from one another by more than four times their diameter, the zones of overstrain caused by their presence (internal notching) do not overlap, and are consequently not so objectionable as when closer together, when their stress effects are mutually superimposed. If close enough, the stress in metal separating them may approach six times the average, and easily pass its elastic limit or ultimate strength. The larger the size of each particle, the greater the chance that another will be found enclosed within the overstressed boundary. Such ideas explain well the fact often encountered that when examining steel, cracks appear between two very small inclusions close together, but nearby single ones much larger have no cracks in their vicinity.

Recent Chemical and Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Process of Treating Copper Ores by Lixiviation With SO_2 Solution.—Niels C. Christensen of Salt Lake City improves the process for the extraction of copper from ores by lixiviation with a sulphur dioxide solution. The leaching solution is kept free from sulphates by the exclusion of air and the formation of copper sulphates is prevented during the leaching and subsequent operations by the addition of metallic copper. Copper is recovered from solution by boiling off SO_2, this latter being used again. The accumulation of iron in the mill solution is prevented by the addition of lime or limestone. (1,316,351; Sept. 16, 1919; assigned to the Metallurgic Improvement Corp.)

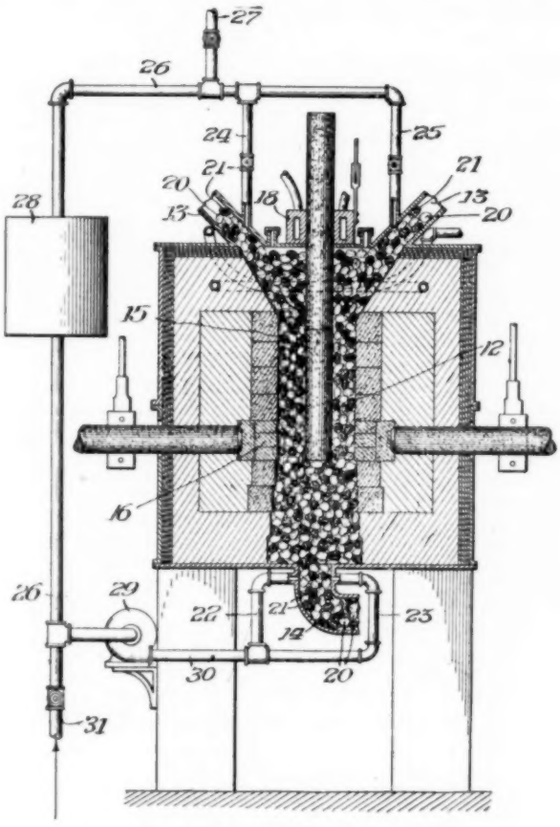
Tungsten Crucible.—Frederick G. Keyes of Hoboken, N. J., produces a tungsten crucible as follows: A form in the shape of a crucible is made by molding pure tungsten powder (sometimes mixed with ½ per cent NiO or with 20 per cent MoO). This form is filled with W_2O_3 or WO_2 and heated in a resistor furnace. This furnace is provided with a means of introducing carbon monoxide. As the tungsten oxides melt they are absorbed by the tungsten powder crucible form and then are reduced by the CO to metal. A homogeneous vessel of pure tungsten results. (1,318,452; Oct. 14, 1919; assigned to the Cooper Hewitt Electric Co.)

Ferro-Alloys.—Two patents have been issued to the estate of the late J. E. Johnson, Jr., on methods of producing ferro-alloys. In the first it is proposed to charge a high-temperature furnace with the usual ingredients for making ferrosilicon, with the exception that a feldspathic mineral is used as the source of silicon. At the high temperature needed to reduce the silica, the feldspar is decomposed and volatile alkaline metals driven off as oxides or carbonates, practically free from mineral acids and easily purified into salts of much value chemically. The fuel on heat consumption of the furnace is not materially greater than when using quartzite in the mix. In the second it is noted that low-carbon alloys can be made in ordinary furnaces (preferably a small blast furnace with enriched oxygen blast) if sufficient temperature is produced to reduce a considerable quantity of silicon from the charge. It appears that silicon has the important quality of excluding carbon from the alloys to a progressive extent as its quantity is increased. This undesirable silicon is then removed on tapping the alloy from the furnace by mixing with a molten reagent, made of iron oxide, lime and a little fluorspar. Silicon then replaces the iron in the reagent, and is fluxed as a lime silicate. (1,318,763 and 1,318,764; Oct. 14, 1919.)

Polyphase Electric Furnace.—Mark Shoeld of Chicago, Ill., provides for the uniform distribution of current flow in polyphase electric furnaces and therefore obtains uniform distribution of heat throughout the material to be treated. This is accomplished by mixing the material in the form of briquets with infusible heat-conducting resistor-elements of a

greater specific conductivity than the briquets. The current tends to flow through the resistor-elements, the material thereby being heated by conduction preventing the fusion of this material. The spacing of the electrodes and their distance from the furnace are important. (1,317,328; Sept. 30, 1919.)

This principle is applied in furnace shown in the illustration. In case aluminum nitride is to be produced the briquets 20 are composed of comminuted carbon, alumina and a suitable binder. The resistor-elements 21 may be composed of carbon. These are fed through chute 13, pass through furnace chamber 12 and are discharged at 14. The furnace has a central electrode 15 and a ring electrode 16. Nitrogen gas is caused to flow up through the furnace charge entering through pipes 22 and 23. This cool gas reduces the temperature of the treated charge and is itself heated, the hot gases after passing the heating zone pass through the incoming charge, heat being transferred to the charge from the gases which pass out through pipes 24 and 25. This gas may be carried by pipe 26 to the scrubber 28 and thence through blower 29 and pipe 30, completing the circuit, or a portion of the gas may be exhausted through pipe 27, in which case the supply is made up by the admission of gas through pipe 31. (1,317,327; Sept. 30, 1919. Both patents assigned to the Armour Fertilizer Works of Chicago, Ill.)



POLYPHASE ELECTRIC FURNACE

Removing Scale From Steel.—QUINTIN MARINS of Hendon, England, proposes the use of 25 deg. Bé. solution of alkaline sulphates and fluids, in proportions of 3 to 1. A carbon or lead anode, a current density of 20 amperes per sq.ft., and a temperature of 75 deg. C. are recommended. (1,324,317; Dec. 9, 1919.)

Book Reviews

CREATIVE CHEMISTRY. By *Edwin E. Slosson, Ph.D.* With an Introduction by Julius Stieglitz. 311 pp., illustrated. New York: The Century Co.

This is an excellent book on popular chemistry, designed to explain the application of the science to industry and daily life to the lay public. Although made up in chief part from a series of papers that appeared in the *Independent*, of which Dr. Slosson is literary editor, it is carefully planned and well put together. It is also richly illustrated. The text is by a man who writes with great ease and experience in the art of expression, and it makes pleasant reading to that part of the public that does not require tam-tams for its ragtime thought. The chapters, which number fourteen, consist of a short historical introduction, Nitrogen, Feeding the Soil, Coal-Tar Colors, Synthetic Perfumes and Flavors, Cellulose, Synthetic Plastics, The Race for Rubber, The Rival Sugars, What Comes From Corn, Solidified Sunshine (referring more particularly to vegetable oils and fats), Fighting With Fumes (or Gas Warfare), Products of the Electric Furnace, and Metals Old and New. These are followed by a well-selected bibliography for extended reading arranged according to subjects, and a good index. Of course, every subject treated is important enough to cover many volumes, but it is fair to say that Dr. Slosson has crowded an unusual amount of information into each chapter. ELLWOOD HENDRICK.

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QUANTITATIVE ANALYSIS BY ELECTROLYSIS. By *Alexander Classen.* Revised, rearranged and enlarged English edition by William T. Hall. xiv + 346 pages. New York: John Wiley & Sons, Inc.

The revision and enlargement of this well-known book is chiefly in the introduction, which comprises about a third of the volume. The application of theory to the procedure in analytical methods tends to clarify the details in the mind of the student. A thorough comprehension of the principles and the application of the electronic theory is therefore essential to the successful use of electrolytic methods of analysis. The discussion in the introduction is well presented from this point of view. The brief historical review of the development of the science of electrochemical analysis is more extensive than in the previous edition. The remainder of the book has been rearranged, the sequence in which the determinations are discussed constituting a more logical presentation of the subject matter. Data consisting of the atomic weight, electrochemical equivalent, electrolytic potential and the overvoltage of hydrogen are given under each element. The revision has added to the value of the book and is sufficient to warrant the presentation of the new edition. L. W. CHAPMAN.

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PROBLEMS OF LABOR AND INDUSTRY IN GREAT BRITAIN, FRANCE AND ITALY. 406 pages. A report of the European Commission of the National Industrial Conference Board, 15 Beacon St., Boston, Mass.

This report by a special commission of industrialists is the result of first-hand observation of conditions in Great Britain, France and Italy during the period immediately following the armistice. The report was prepared in the belief that it would be of assistance to American industry in solving its own problems of industrial readjustment. The report includes investigations into the efficiency of production and methods of stimulating the interest of the worker in increased output; the role of management in its relation to capital and labor; types of organizations of employers and employees; the development of unionism in Great Britain and the attitude of British employers toward it; the system of shop stewards and works committees; the 8-hr. day and the minimum wage; unemployment and housing; types of co-operative schemes and examples of welfare work; a review of the political labor situation in European countries and schemes for nationalizing various British

industries. The commission summarizes its findings in twelve closely printed pages. The widespread discontent among the laboring classes is ascribed mainly to the long strain of the war and the industrial and economic disturbances incident thereto. Fallacious economic teachings, particularly with respect to restricted output, are held responsible for the low efficiency of production. Trade unionism has increased greatly in recent years in all countries visited, but especially in Great Britain, where there is a tendency toward consolidation and unity. This has resulted in forcing British employers to organize among themselves for dealing with trade and labor problems. Shop stewards are seen as a menace, but works committees are considered to be a fair means for bringing employers and workmen together. The movement to establish an 8-hr. day and minimum wage has progressed rapidly in all the countries visited and laws have been passed establishing these principles. The commission found the labor situation "shot through and through with political influence," labor organizations and the socialist parties overlapping to a great extent in membership. Attention was directed to the fact that there has been no organized effort to combat the effect of teachings of socialism, and the commission is of the opinion that "some elementary teaching is needed to show that capital is as essential to industry as labor, and that capital is the one factor of production which assumes practically all the risks and uncertainty and loss."

H. C. PARMELEE.

Personal

Dr. P. G. AGNEW, physicist in the electrical division of the Bureau of Standards, has resigned to become secretary of the American Engineering Standards Committee, with headquarters at the Engineering Societies Building, 29 West 39th St., New York City.

H. C. BARNES has joined the Allegheny Gear Works at Pittsburgh as superintendent of laboratory and metallurgical work. Mr. Barnes is a technical graduate, having been for more than ten years in complete charge of heat treatment for one of the largest gear manufacturers and supervising similar work at one of the large steel mills.

Dr. WALTER H. EDDY, of Teachers College, Columbia University, associate in physiological chemistry, has been appointed assistant professor of physiological chemistry. Dr. Eddy has recently returned from France, where he served fifteen months with the A. E. F. as major in the Sanitary Corps.

H. LIPSON HANCOCK, general manager, Wallaroo & Moonta Mining & Smelting Co., South Australia, is making a visit to the principal copper mining and smelting centers of the United States. He expects to sail from San Francisco some time in March.

ARTHUR G. HENRY, metallurgist for the Illinois Tool Works and secretary of the American Steel Treaters' Society, has resigned to become Chicago representative of the Vanadium Alloys Steel Co.

IRVING H. JONES is now associated with Joseph R. Ryerson & Son in the machinery department, specializing in sales engineering work in the Chicago district.

ROBERT M. KEENEY, consulting engineer of the York Ferro-Alloys Co., will be at York, Pa., for several weeks.

Dr. ARTHUR LACHMAN, a well-known chemist of San Francisco, formerly professor in the University of Oregon, was last seen on the street at noon on Dec. 11, 1919. Since then his family and friends have been unable to obtain any clue or any trace of his whereabouts. It seems probable that he had an attack of amnesia with loss of identity and wandered away. Anyone having information in regard to him is requested to communicate with his family or with Dr. Felix Langfeld, 272 Post St., San Francisco, Cal.

P. E. LANDOLT has been appointed manager of the commercial department of the Research Corp., New York City. Mr. Landolt has been connected with the corporation from its inception.

D. J. LEWIS, JR., formerly with and secretary of W. J. Wayte, Inc., has severed his connection with that company and is now sales agent for the Cresson-Morris Co. and the Kestner Evaporator Co., with headquarters at 277 Broadway, New York City.

W. A. LEDDELL has been appointed manager of the engineering department of the Mine & Smelter Supply Co. with headquarters at Denver, Col.

R. S. MCBRIDE, who has been engineer-chemist of the National Bureau of Standards, resigned on Jan. 15 to join the McGraw-Hill Co. staff in Washington, D. C., as an engineering representative. Mr. McBride was educated at the University of Minnesota, where he received the degree of B.S. in 1908, and at the University of Wisconsin, where he did one year's graduate work and obtained the M.A. degree in 1909. He has been in charge of the gas engineering investigations of the Bureau of Standards for over ten years, specializing in problems of gas supply, gas testing, fuel utilization, byproduct recovery, and the related public utility work of the Bureau. Mr. McBride has been the author or has directed the preparation of over fifty printed articles on various parts of the work as well as had charge of the field studies which have resulted in the preparation of about the same number of engineering and chemical reports not published thus far. As department editor of the *Journal of Industrial and Engineering Chemistry*, a contributor in charge of the Patents and Abstracts sections of the *Gas Record*, and as grand editor of his national fraternity quarterly, the *Hexagon* of Alpha Chi Sigma, Mr. McBride has also had considerable editorial experience.

Dr. FRITZ PANETH, director of the chemical department of the German technical high schools at Prague, has been appointed professor of chemistry at the University of Hamburg, Germany.

L. DUANE SIMPKINS has severed his connection with the Peters Cartridge Co. as metallurgist and chemist, to accept the position of metallurgist with the National Lead Co., Brooklyn, N. Y., in the research laboratory.

LEWIS B. SKINNER, consulting engineer, of Denver, Col., is in New York on business.

PAUL C. SKINNER has been recently made general manager of the General Chemical Co.'s plant at Denver, Col. Mr. Skinner, who has been for years connected with the plant under management of the Western Chemical Co., has worked up through all the departments of the business to the present position under the new management. He has been spending considerable time at the Chicago headquarters recently making arrangements for extensions of plant and business.

Dr. S. A. SOCHOCKY, general technical director of the Radium Luminous Materials Co. of New York, was recently elected president of the company.

WILLIAM A. THOMAS has resigned as president of the Brier Hill Steel Co., Youngstown, Ohio, having been president since 1912. JAMES H. GROSE, formerly general superintendent in the Youngstown district for the Carnegie Steel Co., has been elected to succeed Mr. Thomas.

Dr. WILLIAM H. WALKER, head of the department of applied chemistry at the Massachusetts Institute of Technology, Cambridge, Mass., has been appointed head of the new division of industrial co-operation and research.

Obituary

E. FRED WOOD, formerly vice-president of the International Nickel Co., died suddenly at New York City on Jan. 5, in the sixty-second year of his age. Mr. Wood was born in Milwaukee on Aug. 28, 1858. He was educated in the public schools of his native city and later entered the University of Michigan, where he was a brilliant student and was graduated with distinction. After leaving college Mr. Wood devoted himself assiduously to the study of metallurgy and in connection with his studies made extensive trips through the various mining camps of the

West and lived for a year at Leadville and in other mining towns, where he pursued his studies and obtained his practical experience. He later entered the employ of the Carnegie Steel Co. and rapidly rose to the position of assistant general superintendent of the Homestead plant, which position he filled for a number of years. During the period of the big strike at the plant, when Mr. Frick was shot, Mr. Wood was in entire charge of the plant. He was looked upon by Mr. Carnegie and his associates as one of the valuable men of the organization and was one of the so-called "Carnegie Veteran Associates."

Because of the great reputation that he had achieved he was invited to join the International Nickel Co. upon its organization, becoming first vice-president of the company and a member of the board of directors and of its executive committee, and he was an important factor in developing the mining, smelting and refining business of the company, so that from a small and unimportant undertaking it developed into the largest business of its kind in the world.

When the United States entered the World War, Mr. Wood resigned his official connection with the International Nickel Co. to devote himself to public work, and became a member of the Committee on Production of the War Industries Board, of which committee Samuel Vauclain, president of the Baltimore Locomotive Works, was chairman. Mr. Wood served continuously on this board during the entire period of the war, without compensation. His work on this board was conspicuously fine and of inestimable value and won the admiration and commendation of those who were brought into contact with it. It was the kind of work for which his talents were especially fitted and in which he took particular interest.

Mr. Wood was a man of great learning in his profession and of a wonderful memory, which enabled him to have on tap, ready for use, the result of his many years of study, observation and experience. He was keenly interested in travelling; he visited almost every country on the globe and had the unique distinction of having travelled around the world twice in one year. He was a member of the University of Michigan Club, the Automobile Club, the New York Athletic Club, the Society for Electrochemical Engineers and of the Railroad Club.

Current Market Reports

The Non-Ferrous Metal Market

New York, Jan. 26, 1920—Tin advanced ½c. in the last week. The copper market has been quiet, with price unchanged. The other metals have changed slightly in price in a very few instances.

	Cents per Lb.
Copper, electrolytic	19.50
Aluminum, 98 to 99 per cent	32 @ 33
Antimony, wholesale lots	11.00
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	63.25
Lead, New York, spot	8.62½
Lead, E. St. Louis, spot	8.30
Zinc, spot, New York	9.52½
Zinc, spot, E. St. Louis	9.20
Silver (Dollars per oz.)	1.31¼

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

RARER METALS

Cadmium	lb.	$1.50 @ 2.50
Cobalt	lb.	1.90
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	93.00

SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap	23½ @ 24½
Aluminum, sheet scrap	22½ @ 23½
Aluminum clippings	25½ @ 27
Copper, heavy machinery comp	14½ @ 14¾
Copper, heavy and wire	13½ @ 14
Copper, light and bottoms	12½ @ 12¾
Copper, heavy cut and crucible	15½ @ 16
Brass, heavy	7½ @ 8½
Brass, casting	10½ @ 10¾
Brass, light	5½ @ 6½
No. 1 clean brass turnings	8¼ @ 8½
No. 1 comp. turnings	12 @ 12½
Lead, tea	5½ @ 5¾
Lead, heavy	6½ @ 7
Zinc, scrap	4½ @ 4¾

The Iron and Steel Market

Pittsburgh, January 23, 1920.

Increasing production of steel, with concurrent increase in the anxiety of buyers to coyer for forward deliveries, indicates that there is either a large increase in the actual consumption requirements, present and prospective, or a great increase in the nervousness of buyers. It is not always the case in the steel market that the anxiety of consumers to buy is in precise proportion to their requirements. Sometimes they buy less than they will need and sometimes they have bought more.

The unwillingness of many of the producers in the past few weeks to cover their customers, regular and occasional, has undoubtedly produced some of the anxiety now so apparent. In the case of a number of large producers this conservative policy in the matter of selling has been due to an unwillingness to sell at the March 21 or Industrial Board prices, to which the United States Steel Corporation steadfastly adheres, and at the same time an unwillingness to make formal and regular advances over that schedule. In many cases producers have promised to take care of regular customers' requirements in the second quarter, at prices to be named later, and thus the time has been rapidly approaching at which definite price action must be taken.

Predictions as to the Course of Prices

There are many predictions being made as to the course of prices named by the independents. One possibility, regarded almost everywhere as an unfortunate one, is that there will be a runaway market, prices advancing until the whole structure becomes topheavy, with the natural and inevitable outcome. A prediction that seems reasonable from several aspects is that the larger independents will advance prices of most commodities to the level that obtained between Dec. 12, 1918, when the post-armistice reductions were made, and March 21, 1919, when the Industrial Board reductions went into effect. The December reductions were $4 to $8 per net ton on most finished steel products, with no reductions at all on wire products, while the March reductions were $7 a net ton on all important rolled steel products, with $5 reduction on wire products, including nails, grooved skelp being reduced $5, while universal and sheared were reduced $7. The prediction mentioned, therefore, is that prices will go back to the level of January and February of last year, equivalent to an advance from present basis prices, largely nominal, averaging a little less than $7 a net ton. If this prediction as to finished steel is verified, however, it is unlikely that unfinished steel would advance only by the $5 a gross ton by which it was reduced in March. That would put sheet bars at $47, whereas it seems more probable that they will advance to about $50, and indeed some sales have lately been made to regular consumers at that figure. Sheet consumers, buying for the purpose of having the steel rolled into sheets under contract, would in some cases pay $55 or $60, and some business of this description has been done.

Operating Rates

It may be estimated that the steel mills as a whole are now operating at between 85 and 90 per cent, this comparing with a rate of about 80 per cent at the beginning of the month and an average of not over 60 per cent during the last three months of the old year. The most important restrictive influence now is transportation, this replacing

labor as the chief factor. In point of numbers labor supplies are now practically adequate at most plants. Efficiency and morale of men in employment have increased, but there is still some distance to travel in these respects.

Car shortages are experienced at many plants in the matter of shipping finished products, but not to an extent to cause material to back up against production. Shortages of cars in the Connellsville region for loading coke and at various mines shipping coal to byproduct ovens are a serious limiting factor, and while conditions have been improving somewhat in the past week, the demand for coke keeps well ahead of the supply. More pig iron is being made than at the beginning of the month, but there are still some idle furnaces, awaiting a coke supply, and a number of furnaces are operating with reduced blast pressures to conserve their coke supplies.

Prospects of Demand

There are very conflicting statements as to the prospects of demand for steel for building purposes. In some quarters it is insisted that, labor and material costs as they are, few investors will take hold at present, while in other quarters there are assertions that a very large amount of construction work is in immediate prospect. The requirements of ordinary manufacturing consumers have proved heavier than could be expected. A year ago there was no thought that demand for steel, as a whole, could be as heavy as it has been with the amount of new construction as small as in the past year, and with so little steel passing to the railroads, yet a relatively large quantity of steel has gone somewhere.

As to the railroads, much is being said as to the needs of the railroads, while little is being said, except by railroad officials, as to the ability of the roads to finance purchases, and what the railroad officials say is that they cannot finance purchases unless conditions are made distinctly favorable. The rail requirements are covered very largely either by actual purchases or by reservations, while as to other purchases there may be delays greater than have lately been expected. It is possible that many buyers of steel have deluded themselves in the expctation that the railroads will be heavier buyers in the next few months than will actually prove to be the case, and the course of events will bear careful scritiny from this viewpoint.

The Chemical Market

New York, January 23, 1920.

There has been no change in the general conditions of the market during the past week, prices remaining at the same level. Domestic consumers have not shown a tendency to invest in large stocks at present quotations, preferring instead to contract on future delivery. Manufacturers are sold ahead on contract, and several large factors in the chemical market say they will have nothing to offer until late in 1920.

Heavy Chemicals:—The demand on all grades of *alum* continues strong, but there has not been a large enough demand to warrant an increase in price. The market in *barium* products has been active, with an increase in quotation from \$80@\$85 per ton for barium chloride to \$90@\$100 per ton. The continued coal scarcity has hampered producers of *aqua ammonia*, which is being offered at 8¾c. per lb on spot and 8½c. on contract in drums. *Caustic potash* is steady in demand, export business being about the same as last week, and quotations remain the same at 28@32c. per lb. The demand on *caustic soda* is still very heavy, especially for export. There was a shipment of 450 tons reported during the last week, but this lot about cleans out producers for the time being. The price on the above-mentioned shipment was \$4.25 per cwt., but the price quoted by second hands, who at present control the market on this item, is \$4.50 per cwt. and up, and it is the opinion of some that this item will reach 5c. per lb. shortly. *Sodium nitrite* continues steady in demand, and it is hoped that with the arrival of a large consignment to one of the manufacturers there will be a drop in this product, which at present is quoted at 15@17c. per lb. according to the quantity desired. There have been no new developments in the *alcohol* situation, demand on *ethyl* continuing heavy, while *methyl* is unobtainable. Dealers in the *wood* grade refuse to quote, there being none to be had on spot and contracts have been made so far ahead in some cases that the output will be taken up for several months to come. The scarcity in *formaldehyde*, reported last week, still prevails, this item being practically off the market at present. There has been no change in the producers' quotations of \$12 per cwt. on *acetic acid*, glacial 99½ per cent, during the past week. *Oxalic*, crystals, remains firm at 31@35c. per lb. A bill is now before the House of Representatives to levy a tariff on this item of 5c. per lb. in order to restrict the price on this item.

Coal-Tar Products:—The market still continues scarce in supply, especially in raw materials, and prices are quoted at the same general level. Export inquiry has been heavy, with difficulty on the part of the producer in meeting this demand. *Aniline oil* and *salt* continue firm, prices holding from last week, 34@36c. per lb. on the former and 45@50c per lb. on the latter. *Toluol* is easier at 28c. per gal. in tanks and 29c. in drums, with a somewhat larger supply on hand. One large producer of H acid has stopped quotations on this item, as he is contracted up to June, with all available spot material in second hands.

Waxes:—This branch of the market during the past week has continued firm, any action in price being caused by an actual scarcity of spot material on hand. There has been a noticable stiffening in all lines of the paraffine grade, of ¼c. to ½c. on each item. Japan continued active at 19½@20c. per lb. for the usual requirements, but no large orders have been placed.

Flotation Oils:—Considerable activity in demand has been the feature of this market during the past week. A general increase in price of all items has been caused by an increased demand combined with a natural scarcity of crude materials. *Pine oil*, steam distilled, sp.gr. 0.930-0.940, jumped from \$1.38 to \$1.45 per gal., while pine tar oil, crude, sp.gr. 1.025-1.035, tank cars, f.o.b. Jacksonville, Fla., jumped from 35c. to 48c. per gal. *Crude turpentine*, in sympathy with the spirits and under heavy demand at present, has had a rise from \$1.40 to \$1.60 per gal.

Naval Stores:—*Spirits of turpentine* remains the center of attraction in this market, quotations remaining \$1.97@ \$2 per gal. There has been no relief in the London market, and demand still continues brisk, with a threatened upward price. The situation will be relieved only by the dropping out of the bullish element of the market. Demands, both export and domestic, have been heavy on the New York market for *turpentine* and *rosin*, Grade B, which is quoted at \$19.50 per 280 lb.

Vegetable Oils:—*Linseed Oil* has shown a slight indication of coming back during the past week, though the amount of actual business recorded has been small. No immediate large demand is expected by dealers, but it is expected that the coming season will bring a larger demand by consumers than was placed last year. Most of the present output is used to fill contracts made last year for future deliveries. The quotation still remains \$1.72 per gal. Stocks of *soya bean* and *peanut oil* are diminishing, while no large stocks of *cocoanut oil* are to be found on spot in the market. There has been a general strengthening during the past week in this market, prices remaining steady, but buyers are somewhat wary of existing prices.

St. Louis, January 21, 1920.

The good demand for heavy chemicals which has been manifested since the first of the year continues in St. Louis. The demand for *sulphuric acid*, which slumped last month, has stiffened in the last two weeks. There is very little spot buying; the reason being small stocks, not few inquiries. Contract buyers are having no trouble in filling their requirements, however. Local men look for this condition to continue on account of the absorption of surplus stocks. A slight rise in prices is predicted.

Sulphuric Acid:—The demand for this chemical is picking up due to the fact that conditions in the coal business are getting back to normal and there has been an easing up of the phosphate rock situation. It is almost back to normal at

present and as soon as operations in the oil fields are in full swing once more this chemical will be in heavy demand. Prices have started to rise now over what they were two weeks ago. The 60 deg. grade is quoted at $14@$15 a ton, where two weeks ago it was at $12@$14, according to quantity. The 66 deg. grade has gone from $18 to $20 a ton, though oleum is still quoted at $25 a ton, as it was two weeks ago.

Muriatic Acid:—There is a normal movement in this chemical, it having recovered from the slight slump it was in two weeks ago. There have been a number of inquiries and producers report several sales. It is quoted at $22 a ton for the 18 deg. grade.

Sodium Sulphate:—There is a fair inquiry for this chemical, though not many sales have been reported in the last week, none of them being over $20 and the average being $19.50.

Sodium Bisulphate:—The movement in this chemical is better than at the beginning of the month, though there has been no change in price. Several large contracts have been closed during the past week, all of them at the low price prevailing the first of the year, $2.50. On account of the fact that these large contracts will remove part of the supply from the market, producers look for the price to rise in the near future.

Nitric Acid:—There is little demand for this acid and the market remains at 10@10½c. per lb. for 38 deg.

Zinc Chloride:—There is a greatly increased demand for this, due to the fact that the manufacturers of creosoting oils have resumed operations in full swing. This may be attributed to the fact that when the railroads are turned back to the hands of the private owners there will be a big demand for railroad ties, many of the roads having been neglected in that respect by the Railroad Administration.

Zinc Oxide:—Advices have been received here that Eastern manufacturers have raised prices ½c. a lb. on bbl. shipments for all grades except the high-leaded zinc oxide, 20 and 30 grades, which have been raised ¾c. a lb. on bbl. shipments. No advances have been made yet by local makers. The demand is strong and many orders are on the books for immediate shipment and plants are working to their capacity to keep pace with the orders. It has been necessary during the past week to make advances in labor wages, and all things indicate prices will advance later on.

Phenol:—This is in very good demand for domestic consumption, practically all on the market being Government material, which a St. Louis chemical concern has contracted to market. In 15-ton lots, f.o.b. St. Louis, Philadelphia or New York, it is bringing 12c. per lb., with smaller quantities at slightly higher prices. There is a shortage of this item for export purposes.

Chicago, January 21, 1920.

Remarkable steadiness is shown in all lines this month, with the general tendency upward. Steady domestic demand, increasingly heavy exports of certain items and greater producing costs have combined to produce the present strong market, and the fact that many producers are under contract for their full output for some time will tend to prolong present conditions. A comment heard among manufacturers is that it seems impossible to procure as heavy production today as was the case in the past with the same plant and force of men, seeming to indicate that the lessened efficiency of labor, so often noted in other lines, is now felt in the production of chemicals.

Heavy Chemicals:—Exports of *granulated caustic soda* to Europe and the Orient continue heavy and the price remains firm as last quoted—$4.50 per cwt., in carloads, f.o.b. works. The solid is firm at $4. So much of the future output of caustic is under contract at these figures that spot stock buyers will probably be asked even more for some months to come. *Bleaching powder* and *soda ash* are also in heavy demand for export, considerable quantities being put under contract for shipment to the Far East. *Bleaching powder* in carlots is bringing $2.50@$2.60 per cwt. for immediate shipment, with producers showing no anxiety for long-term contracts. *Soda ash* is worth $1.75 per cwt. on contracts for future delivery, and $2.10 is asked in cars f.o.b. works for spot shipment. *Sodium bicarbonate* is also in good tone, with $2.75 per cwt. asked for spot delivery in less than carlots, $2.40 in cars, f.o.b. factory. *Niter cake* (sodium bisulphate) is in fair demand at $7@$7.50 per ton in large quantities.

Sodium bichromate, which was completely out of hand in the local market a month ago, is back again at 20c. in bbl. lots and indications are that this figure will hold good for some time. *Formaldehyde* presents the most spectacular advance of the month. It is much in demand, is very scarce, and 50c. per lb. is asked for the limited quantities available. *Alcohol*, also, is in good demand, with *ethyl* quoted in less than carloads at from $5.30@$5.50 per gal. *Methyl* is even stronger, available spots going freely at $1.80 in reasonable quantities. *Oxalic acid*, under heavy demand from the dyestuffs, manufacturers, is high and short in supply, 40c. a lb. now being quoted in barrels.

Roll sulphur (brimstone) has developed a very strong tone, price from factory being about $3.80 per cwt. in cars. This item is quoted by jobbers as high as 5c. per lb. in bbl. lots. Acids, except for oxalic as mentioned above, remain quiet, the demand still being somewhat below normal, with 66 deg. sulphuric quoted at $20 a ton in quantities, and 20 deg. hydrochloric (muriatic) at $2.25 per cwt. in less than carloads. With the gradual straightening out of the steel industry the acid market should show considerably more strength, as with consumption in full swing manufacturers will be hard pressed to supply the needed quantity.

Coal-Tar Products:—Very severe shortage of *benzol* has forced the price even higher than it was at the end of the coal strike, the current price being 33c. *Toluol*, being in slightly better supply, is selling at 27c. in tanks, with deliveries fairly prompt. Continued short supply of *anilines* has forced the *oil* up to 35c. and *salts* to 45c. These prices are for small quantities only, no large supplies being available. Very little business for future delivery is reported.

Benzoic acid is slightly firmer, 95c. being current quotation for U.S.P. and 78c. for technical in wholesale quantities. *Picric acid* shows no change from the former quotation of 20c., but excess stocks are dwindling and an advance is looked forward to shortly. *Salicylic*, under moderate demand, remains at 44c. per lb. for the technical grade.

Vegetable Oils:—This entire line shows considerable strength, except in *corn oil*, which is being freely offered at 17½c. in sellers' tanks, and *cottonseed oil*, which shows only fair demand at 19½c. for crude and 24c. for prime summer yellow in barrels. *Cocoanut oil* is in excellent demand, 18½c. per lb. ruling for Manila grade in sellers' tanks, f.o.b. Pacific coast. Similar grade in barrels is bringing 19½c. in Chicago. *Soya bean oil* is also much wanted, the market being strong at 17½c. in barrels.

Flotation Oils; Naval Stores:—Having thoroughly recovered from the slackening in demand occasioned by the fuel strike, *pine tar products* are developing such heavy demand as to guarantee a strong market for some time. Distilled pine tar oil, .933 pure, is easily sold at the current quotation of $1.50 and a rapid increase in price is expected. The *destructively distilled* grade carries the same price and is even harder to get. *Turpentine*, in cars, is quoted at $2 @$2.05 per gal. f.o.b. Chicago, and the jobbers' price in barrels is $2.16. Actual needs in the various industries are in excess of supply and it is hard to tell how high the market may climb before the new crop comes in March.

Rosin, likewise, is scarce and high priced. It is noted that the first exportation of rosin to Germany since 1914 occurred last week, when 1,500 bbl. left Savannah, and inquiries are being received in the local markets from Bavarian consumers. Ruling prices are, for F grade, $20.20 per cwt. in barrels, delivered, and for WW grade, $24.50@$25. Fluctuation is so rapid that these quotations may be considered nominal.

Fertilizers:—With stocks still suffering from the depletion which occurred during the fuel shortage and with both domestic and foreign demand strong, prices are on the up grade. Ground blood at $7.85 and unground blood at $7.65 have scored higher than at any time last year.

Tankage is also in strong demand, high-grade ground being quoted at $7.50 and bone meal, raw, is now sold at $44.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.60 – $0.65
Acetone	lb.	$0.16 – $0.20	.21 –
Acid, acetic, 28 per cent	cwt.	2.50 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric (muriatic), tech. 20 deg.	cwt.	2.50 –	2.60 – 2.75
Hydrofluoric, 52 deg.	lb.	.12 –	.14 –
Lactic, 44 per cent tech.	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech.	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.	–	4.00 – 4.25
Nitric, 40 deg.	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg.	lb.	.06½ – .07	.08 –
Oxalic, crystals	lb.	.31 – .32	.32 – .35
Phosphoric, Ortho, 50 per cent solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.20 – 2.40	2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	–
Sulphuric, 60 deg., drums	ton	– 30.00	–
Sulphuric, 60 deg., carboys	ton	–	–
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	–
Sulphuric, 66 deg., drums	ton	–	–
Sulphuric, 66 deg., carboys	ton	–	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	25.00 –	30.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –	32.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 –
Tannic, U. S. P.	lb.	–	1.35 – 1.45
Tannic (tech.)	lb.	–	.42 – .55
Tartaric, crystals	lb.	–	.69 – .74
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	–	.76 – .78
*Alcohol, denatured, 190 proof	gal.	–	.71 – .73
Alum, ammonia lump	lb.	.04½ – .05	.04½ – .04¾
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	–	.30 – .33
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white sal ammoniac)	lb.	.12½ – .14	.13½ – .17½
Ammonium chloride, granular (gray sal ammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.22 –	–
Ammonium sulphate	lb.	.05 –	.06 –
Amylacetate	gal.	–	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	–	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	–
Barium chloride	ton	80.00 – 85.00	100.00 – 110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 –
Barium nitrate	lb.	.09½ .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03½ – .04
Bleaching powder (see calcium hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.90 – .95	–
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	–	.04½ .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	–	2.50 – 3.75
Calcium peroxide	lb.	–	1.50 – 1.70
Calcium phosphate, monobasic	lb.	–	.75 – .80
Calcium sulphate, pure	lb.	–	.25 – .30
Carbon bisulphide	lb.	.05½ –	.06 – .09
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	–	.75 –
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 –
Cobalt oxide	lb.	–	1.50 – 1.55
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	–	.28 – .31
Copper cyanide	lb.	–	.65 – .70
Copper sulphate, crystals	lb.	.07½ – .08½	.09 – .09½
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	2.30 – 2.50
Formaldehyde, 40 per cent	lb.	–	.51 – .52
Glauber's salt (see sodium sulphate)		–	–
Glycerine	lb.	–	.24½ – .26
Iodine, resublimed	lb.	–	4.10 – 4.30
Iron oxide, red	lb.	–	.03 – .20
Iron sulphate (copperas)	cwt.	1.00 –	1.20 – 1.75
Lead acetate, normal	lb.	–	.20 – .23
Lead arsenate (paste)	lb.	–	.13 – .17
Lead nitrate, crystals	lb.	–	.30 – .35
Litharge	lb.	–	.09½ – .10¼
Lithium carbonate	lb.	–	1.50 –
Magnesium carbonate, technical	lb.	–	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	–	.75 – .90
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.28 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	–	.56 – .60
Potassium bromide, granular	lb.	–	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 –
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.23 – .32	.35 – .42
Potassium iodide	lb.	–	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	–	.65 – .95
Potassium prussiate, red	lb.	–	1.10 – 1.20
Potassium prussiate, yellow	lb.	–	$0.40 – $0.70
Potassium sulphate	ton	$225.00 –	–
Rochelle salt (see sodium potas. tartrate)		–	–
Sal ammoniac (see ammonium chloride)		–	–
Sal soda (see sodium carbonate)		–	–
Salt cake (sodium sulphate)	ton	18.00 – 21.00	–
Silver cyanide	oz.	–	1.25 –
Silver nitrate	oz.	–	.81½ – .82½
Soda ash, light	100 lb.	2.05 –	2.25 –
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.20 – .21	.22 – .25
Sodium bisulphate (nitre cake)	ton	6.00 – 8.00	10.00 –
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	– .08	.08½ – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	–	4.30 – 4.50
Sodium hyposulphite	lb.	–	.03½ – .04
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	– .18
Sodium peroxide, powdered	lb.	–	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04¼	.04¼ – .05
Sodium potassium tartrate (Rochelle salt)	lb.	–	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .39	.24 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¼ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.03½ – .04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc.)	lb.	–	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.43 –	.60 –
Zinc carbonate, precipitate	lb.	–	.20 –
Zinc chloride, gran.	lb.	.12½ –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 –
Zinc dust	lb.	.09 – .11	.11 – .14
Zinc oxide, dry American	lb.	–	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.34 —	.36
Aniline oil, drums extra	lb.	.34 —	.36
Aniline salts	lb.	.45 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Bensidine, base	lb.	1.25 —	1.30
Bensidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.52
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech.	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U.S.P., in drums (100 lb.)	lb.	.18 —	–
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.75 —	.80
Cresylic acid, 95-97%, dark, in drums	gal.	.72 —	.75
Cresylic acid, 50%, first quality, drums	gal.	.60 —	–
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline	lb.	.90 —	1.00
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.27 —	.30
Ortho-amidophenol	lb.	3.00 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.15 —	.18
Paranitraniline	lb.	1.00 —	1.20
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.60 —	1.00
Phenol, U.S.P., drums (dest.), (240 lb.)	lb.	.12½ —	.19
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.55 —	.60
Salicylic acid, U.S.P.	lb.	.42 —	.50
Salol	lb.	.90 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.22 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

Toluidine	lb.	$1.70 —	$2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	....
Xylol, commercial, in drums, 100 gal	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white, pure	lb.	.63 —	.68
Carnauba, No. 1	lb.	.80 —	.88
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.46 —	.48
Japan	lb.	.18½ —	.20
Paraffine waxes, crude match wax(white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.... —	.07
Paraffine waxes, refined, 118-120 m.p.	lb.	.... —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½ —	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	.... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist	gal.	....
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp.gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots:

Rosin B-D, bbl	280 lb.	$17.00 —	$17.50
Rosin E-I	280 lb.	17.85 —	18.40
Rosin K-N	280 lb.	19.75 —	22.50
Rosin W. G.-W. W	280 lb.	22.50 —	24.25
Wood rosin, bbl	280 lb.	17.00 —	17.50
Spirits of turpentine	gal.	.... —	1.97
Wood turpentine, steam dist	gal.	.... —	1.70
Wood turpentine, dest. dist	gal.	1.64 —	....
Pine tar pitch, bbl	200 lb.	8.25 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	14.75
Retort tar, bbl (500 lb.)	bbl.	15.00 —	15.25
Rosin oil, first run	gal.	.... —	.91
Rosin oil, second run	gal.	.93 —	.94
Rosin oil, third run	gal.	1.10 —	1.12
Rosin oil, fourth run	gal.	.... —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naptha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.47½ —	$0.48½
Upriver coarse	lb.	.34 —	.35
Upriver caucho ball	lb.	.33½ —	.34½
Plantation—First latex crepe	lb.	.52 —	.54½
Ribbed smoked sheets	lb.	.51½ —	....
Brown crepe, thin, clean	lb.	.48 —	.48½
Amber crepe No. 1	lb.	.53 —	....

Oils

VEGETABLE

The following prices are f.o.b., New York, for carload lots:

Castor oil, No. 3, in bbls	lb.	$0.18 —	$0.19
Castor oil, AA, in bbls	lb.	.21 —	.23
China wood oil, in bbls	lb.	.23½ —	.24½
Cocoanut oil, Ceylon grade, in bbls	lb.	.20 —	.20½
Cocoanut oil, Cochin grade, in bbls	lb.	.20½ —	.23
Corn oil, crude, in bbls	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19 —	.20
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	1.87
Linseed oil, raw, tank cars	gal.	1.70 —	1.80
Linseed oil, boiled, car lots	gal.	1.75 —	1.80
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.17 —	.18
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½ —	.24
Peanut oil, refined, in bbls	lb.	.27 —	.28
Rapeseed oil, refined in bbls	gal.	1.45 —	1.68
Rapeseed oil, blown, in bbls	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17½ —	.20

FISH

Winter pressed Menhaden	gal.	$1.20 —	....
Yellow bleached Menhaden	gal.	1.23 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.26 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	$ .04½ —	$ .06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00 —	35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00 —	45.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, TN	lb.	1.10 —	1.15
Shellac, D. C	lb.	.... —	....
Shellac, V. S. O	lb.	.... —	....
Shellac, Diamond I	lb.	.... —	....
Shellac, orange, fine	lb.	1.25 —	....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	....
Shellac, bleached, bone dry	lb.	1.35 —	....
Shellac, bleached, fresh ground	lb.	1.10 —	1.15
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	1,000	41-45 at Mt. Union, Penn.

Ferro-Alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome per lb. of Cr contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome per lb. of Cr contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn	gross ton	140.00 —	150.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.25 —	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00 —	....
Ferro-vanadium, 30-40% per lb. of contained V	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	.... —	14.00
Fluorspar, gravel, f.o.b. mines	net ton	.... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	....
Pyrites, foreign, lump	unit	.17 —	....
Pyrites, foreign, fine	unit	.17 —	....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	....
Rutile, 95% TiO_2	lb.	.11 —	....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	....
Monazite, per unit of ThO_2	unit	42.00 —	....

* Government prices.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.80
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	16.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	48.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	50.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	40.00
Roofings, tar felt (14 lb. per 100 sq. ft.)	ton	70.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	63.00
Roofings, slate-surfaced, per roll of 108 sq. ft. carlots		2.25
Roofings, slate-finished shingles, 100 sq. ft. carlots		6.00
Linseed oil, raw in barrels	gal.	1.75
Linseed oil, 5 gal. cans	gal.	1.90
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.15½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

CHANDLER—The Bd. Educ. will receive bids until Feb. 14 for the construction of a high school, including a science building. Estimated cost, $150,000. Allison & Allison, 1405 Hibernian Bldg., Los Angeles, Cal., archts.

California

EL SEGUNDO—The Standard Oil Co., 200 Bush St., San Francisco, has awarded the contract for the construction of additions and improvements to its refinery, to the Foundation Co., Holbrook Bldg., San Francisco. Estimated cost, $2,000,000.

Connecticut

WINDSOR—The General Electric Co., Lynn, Mass., will soon award the contract for the construction of a 3-story, 67x200-ft. manufacturing building.

Maryland

BALTIMORE—The Mutual Chemical Co. of America, Block and Wills Sts., has awarded the contract for the construction of a 2-story, 100x200-ft. addition to its chemical plant at 1348 Block St., to Morrow Bros., 1201 Fidelity Bldg. Estimated cost, $60,000.

Massachusetts

PITTSFIELD—The General Electric Co., Morningside, will build a 1-story, 80x400-ft. enameling building addition. Work will be done by day labor.

WEST MEDFORD (Boston P. O.)—The Warner & Childs Paper Co. has awarded the contract for the construction of a 4-story, 100x225-ft. factory on Boston Ave., to W. M. Bailey Co., 88 Broad St., Boston.

Michigan

DETROIT—The Butt Welding & Mfg. Co., Bellevue and Warren Aves., plans to build a 20x100-ft. building. F. W. Biederman, mgr.

DETROIT—The Detroit Grey Iron Fdry. Co., Wight St., has awarded the contract for the construction of a 2-story, 135x150-ft. foundry, to J. L. Kolley, 3563 Jefferson Ave.

GRAND RAPIDS—The Bd. Educ. plans to construct a 3-story, 225x250-ft. school, to be known as the North Junior High School, on Plainfield Ave. Chemical laboratory equipment will be installed in same. H. H. Turner, 234 Division Ave., N., archt.

Minnesota

MESABA—D. C. Jackling and Haydon & Stone, 25 Broad St., New York City, plan to construct 10 concentration plants on various points on Mesaba Range. The first unit will cost $3,000,000, ultimate cost $30,000,000. Dwight E. Woodbridge and Walter G. Swart, 808 Sellwood Bldg., Duluth, engrs.

Missouri

ST. LOUIS—D. A. Blanton Co., 2nd and Spruce Sts., has awarded the contract for the construction of a 2-story, 73x151-ft. oleomargarine factory at 319-23 South 1st St. and 101-11 Spruce St., to the Kellerman Constr. Co., International Life Bldg. Estimated cost, $50,000.

ST. LOUIS—The Emerson Electric Co., 2100 Washington St., has awarded the contract for the construction of an 8-story, 129x150-ft. factory at 2012-20 Washington St. and 2011-19 St. Charles St., to the Murch Bros. Constr. Co., Ry. Exch. Bldg. Estimated cost, $400,000.

ST. LOUIS—James D. Howe, 5811 De Giverville St., has purchased a site on the Natl. Bridge Rd., and plans to construct a 3-story, 117x250-ft. factory for the manufacture of patent medicines. Estimated cost, $20,000.

New Hampshire

NORTH STRATFORD—The Warner Sugar Refining Co., 79 Wall St., New York City, plans to build a sugar refinery. Estimated cost, $1,000,000.

New Jersey

TRENTON—The Mercer Motor Co., Whitehead Rd., will soon award the contract for the construction of a 1-story, 80x400-ft. paint shop addition to its plant. Estimated cost, $50,000.

VERONA (Montclair P. O.)—The Eagle Rock Mfg. Co. is having plans prepared for the construction of a 2-story, 40x350-ft. factory for the manufacture of moving picture films. Estimated cost, $250,000. Lockwood, Green & Co., 101 Park Ave., New York City, archts. and engrs.

New York

OGDENSBURG—Williams & Johnson, archts., are preparing plans for the construction of a factory for the manufacture of electrical fixtures, plumbers' supplies and brass articles, on the Wright property in the East End of city, for Cooper's Brass Wks., Inc. Estimated cost, $100,000. Address R. J. Donahue, Ogdensburg, or Abraham Cooper, 16 Nassau St., Brooklyn.

WATERTOWN—The Bagley & Sewall Co., mfr. of paper-making machinery, has purchased a site in the vicinity of its plant on East Moulton St., and plans to build a plant for the manufacture of pulp screens. The company recently acquired the equipment and good will of the Harmon Machine Co., manufacturer of the "Harmon Inclined Pulp Screens."

Ohio

CINCINNATI—The Rapid Electrotype Co., Canal, Race and Elm Sts., has awarded the contract for the construction of a 2-story, 100x215-ft. factory on McMicken, Race and Elm Sts., to L. Schrieber & Sons, Ivanhoe Ave.

CLEVELAND—The National Carbon Co. has awarded the contract for the construction of a 1-story, 120x180-ft. furnace building on West 117th St. and Madison Ave., to the Crowell, Lundorff, Little, Bicknell Co., 5716 Euclid Ave. Estimated cost, $200,000.

WARREN—The Goheen Mfg. Co. has awarded the contract for the construction of a 5-story, 50x125-ft. paint factory, to the Craig-Curtis Co., 1031 Guardian Bldg., Cleveland. Estimated cost, $200,000.

Oklahoma

WILBERTON—The city is having preliminary plans prepared for the construction of a 6 to 12 in. pipe sewer, sewage disposal plant, and 13,000 ft. of flow line and main extensions. An Imhoff tank will be installed in same. Estimated cost, $100,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, engr.

Oregon

ASTORIA—W. H. Goodnough and associates plan to construct a 2- or 3-story, 50-ton daily capacity, pulp and paper plant and have asked the Port of Astoria Comn. to investigate a site for same. Estimated cost, $500,000.

Pennsylvania

FRANKFORT (Philadelphia P. O.)—The Belmont Packing & Rubber Co., 133 North 2nd St., Philadelphia, plans to build a 2 story, 120x120-ft. factory. Estimated cost, $60,000. Carl P. Berger, South Pennsylvania Square Bldg., archt.

Wisconsin

MILWAUKEE—The Central Bd. of Purchases, City Hall, will soon award the contract for furnishing 35,000 lb. of liquid chlorine.

Ontario

CHATHAM—The city plans to construct a new water system, to include rapid sand filters, 250,000-gal. steel tank, etc. A by-law appropriating $300,000 for the project has been passed. E. A. James Co., Ltd., 36 Toronto St., Toronto, engr.

OWEN SOUND—The Aluminum Steel Products, Ltd., plans to build an extension to its plant. Estimated cost, $250,000.

SCARBORO—The town plans to construct two pumphouses to be equipped with rapid sand filters, chlorinating apparatus, etc. A bylaw appropriating $300,000 for this project has been passed. E. James Co., Ltd., 36 Toronto St., Toronto, engr.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention in St. Louis, May 10 and 11.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23 to 26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will have a joint meeting with the American Chemical Society and the Society of Chemical Industry, Feb. 6, 1920. On Feb. 27 another meeting will be held, the subject for which is "Electric Furnace Reducing Agents." Another meeting will be held on March 26, the subject of which is Peace Uses for War Products.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16 to 19.

THE FARADAY SOCIETY (London) will hold a joint meeting, March 1, with the London Section of the Society of Chemical Industry to receive and discuss a report of Dr. T. Martin Lowry, and E. C. Hemmings on the "Setting of Salts and Other Crystalline Substances." Another meeting will be held March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W., 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE MATERIAL HANDLING MACHINERY MANUFACTURERS' ASSOCIATION has found it necessary to change the date of its convention at the Waldorf-Astoria Hotel, New York City, from Jan. 29 and 30, to Feb. 26 and 27.

Industrial Notes

THE ROYAL GRAND OIL CO., El Paso, Tex., plans the addition of another unit of 1000-bbl. capacity to its El Paso refinery. This will give a total capacity of 2000 bbl. of crude oil daily.

THE CLIMAX MOLYBDENUM CO., which is associated with the American Metal Co., 61 Broadway, New York City, now has in press a 72-page book on molybdenum commercial steels. The book is the first of its kind to be published, and contains tables, colored charts, microphotographs and other illustrations. It will be sent upon request without charge.

THE NORVELL CHEMICAL CORP., of Perth Amboy, N. J., was incorporated Jan. 1, 1920, in the State of Delaware with an authorized capital of $1,000,000 of preferred stock, and with 20,000 shares of common stock, no par value. The company has taken over from McKesson & Robbins, Inc., the property near Perth Amboy, N. J., consisting of 350 acres of land and a number of factory buildings erected on the property, purchased last year by McKesson & Robbins, Inc., also additional works which have since been constructed on the property, and will operate the plant, supplying the medical profession and the drug trade with pharmaceutical chemicals and the industries with chemicals useful in the manufacture of a variety of products. The company has gathered a staff of highly trained chemists for research work and expects to develop new and useful processes for the manufacture of chemical products. At a stockholders' meeting held at the temporary New York office at 11 Cliff St., the following directors and officers were elected: President, Donald McKesson; vice-president and treasurer, Saunders Norvell; second vice-president, Francis J. McDonough; secretary, William S. Gray, Jr.; assistant treasurer and assistant secretary, James J. Crawford. George Simon was appointed general manager.